Agro-Environmental Impact Assessment and Farm Management

Low-Imput Farming Systems

Christos Vasilikiotis, Ph.D.

Low-imput farming systems

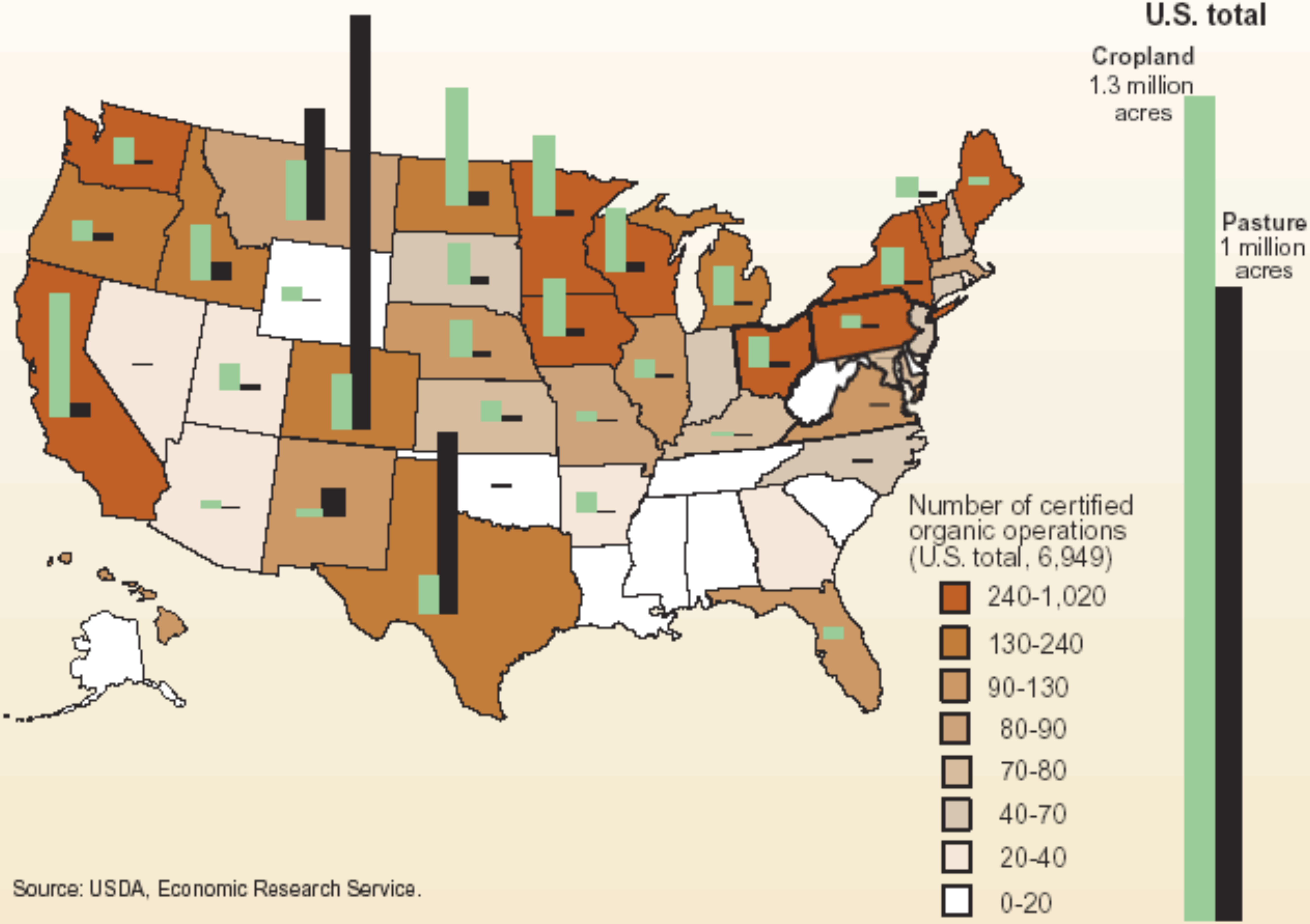
- Organic Farming
- Biodynamic
- Bio-intensive
- Permaculture
- Traditional Farming

Organic Agriculture

Definition

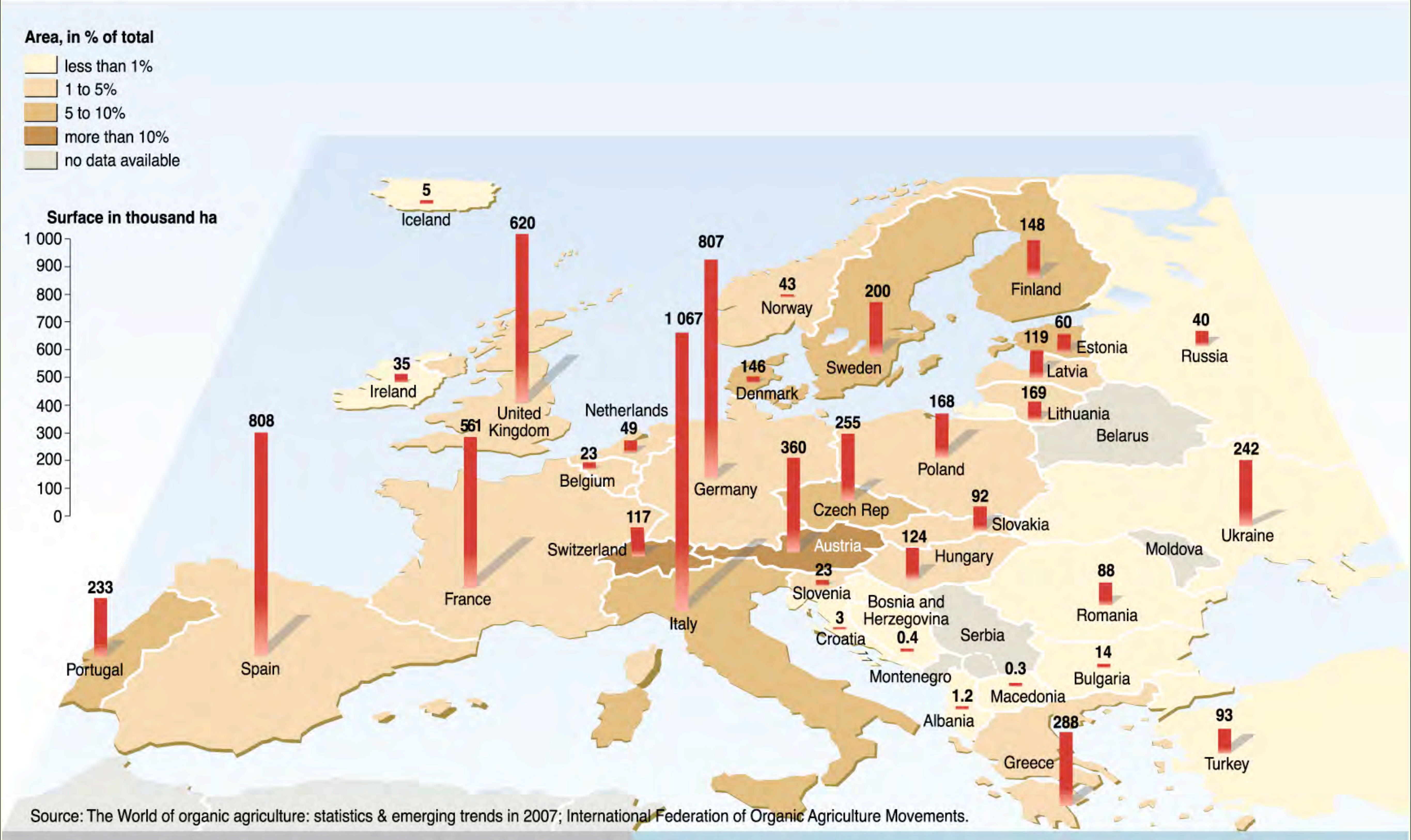
According to the proposed FAO Codex definition, "organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfill any specific function within the system."

Certified organic acreage and operations, 2001



Source: USDA, Economic Research Service.

Organic farming in Europe



Source: The World of organic agriculture: statistics & emerging trends in 2007; International Federation of Organic Agriculture Movements.

Organic Weed Management

- Hand weeding
- Mulch
- Corn gluten meal
- Vinegar
- Flame weeding
- Crops such as rye

Organic Pest Management

- Biocontrol – using natural predators to control pests (e.g. Ladybugs, spiders)

- Row covers
- Crop rotation
- Organic approved pesticides e.g. Surround, garlic, neem, BT, pyrethrum

Why does organic food cost more?

- Organic farming involves more risk
- Limits on pesticides means more hand weeding
- Compost and manure are bulkier than synthetic fertilizers so cost more to transport
- Crop rotation means you can’t grow your highest value crop every year
- Demand exceeds supply
- Certification costs
- Organic farmers do not receive the same subsidies

Pest Management

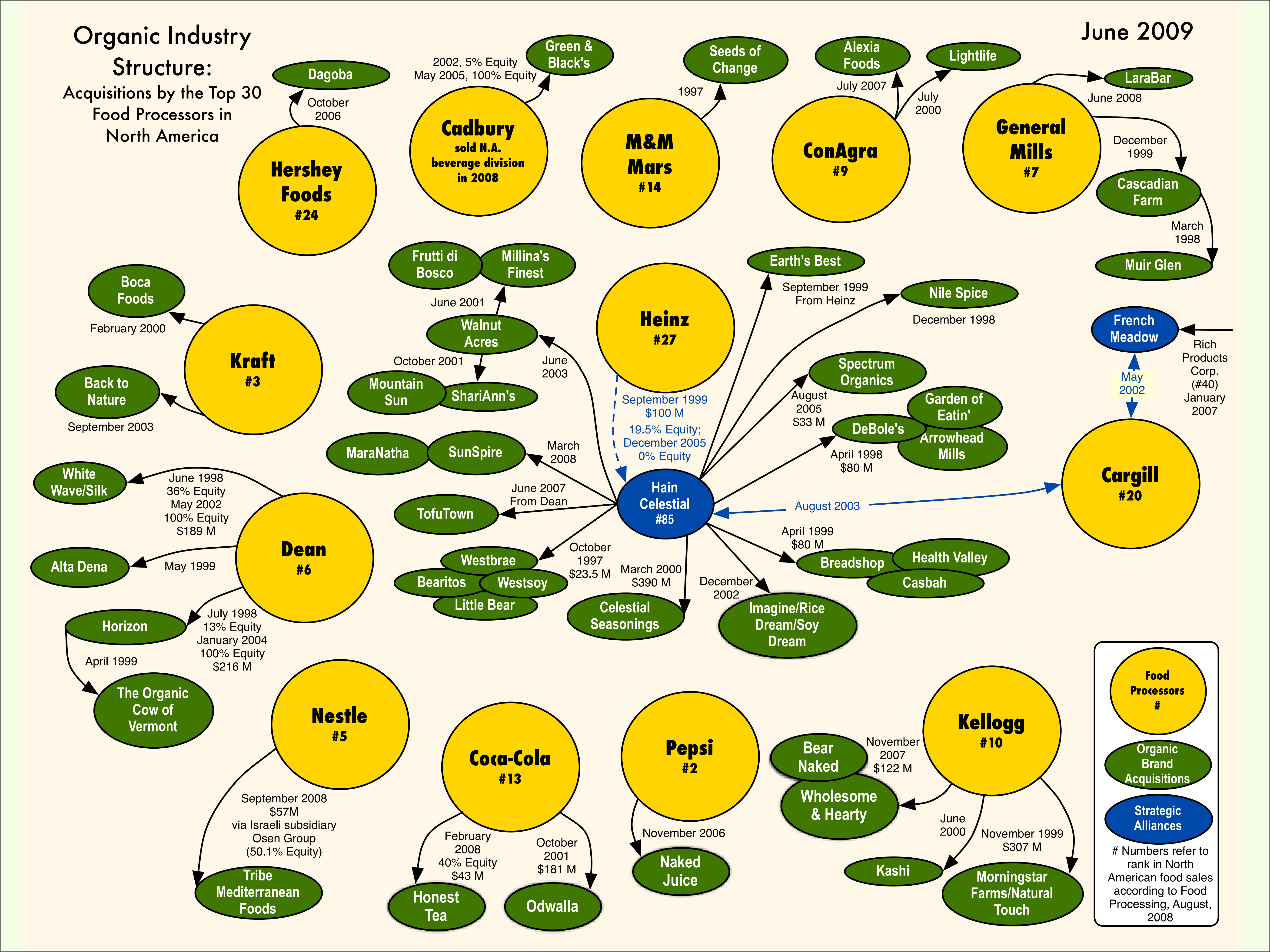
- Biological
  - Crop rotation
  - Soil fertility
  - Cultivars
  - Biological control
- Physical
  - Tillage
  - Cultivation
  - Barriers
  - Traps
  - Temporal
- Chemical
  - Attractants
  - Botanicals
  - Rotenone
  - Pyrethrum
  - Bt
  - Repellents

Soil Fertility Management

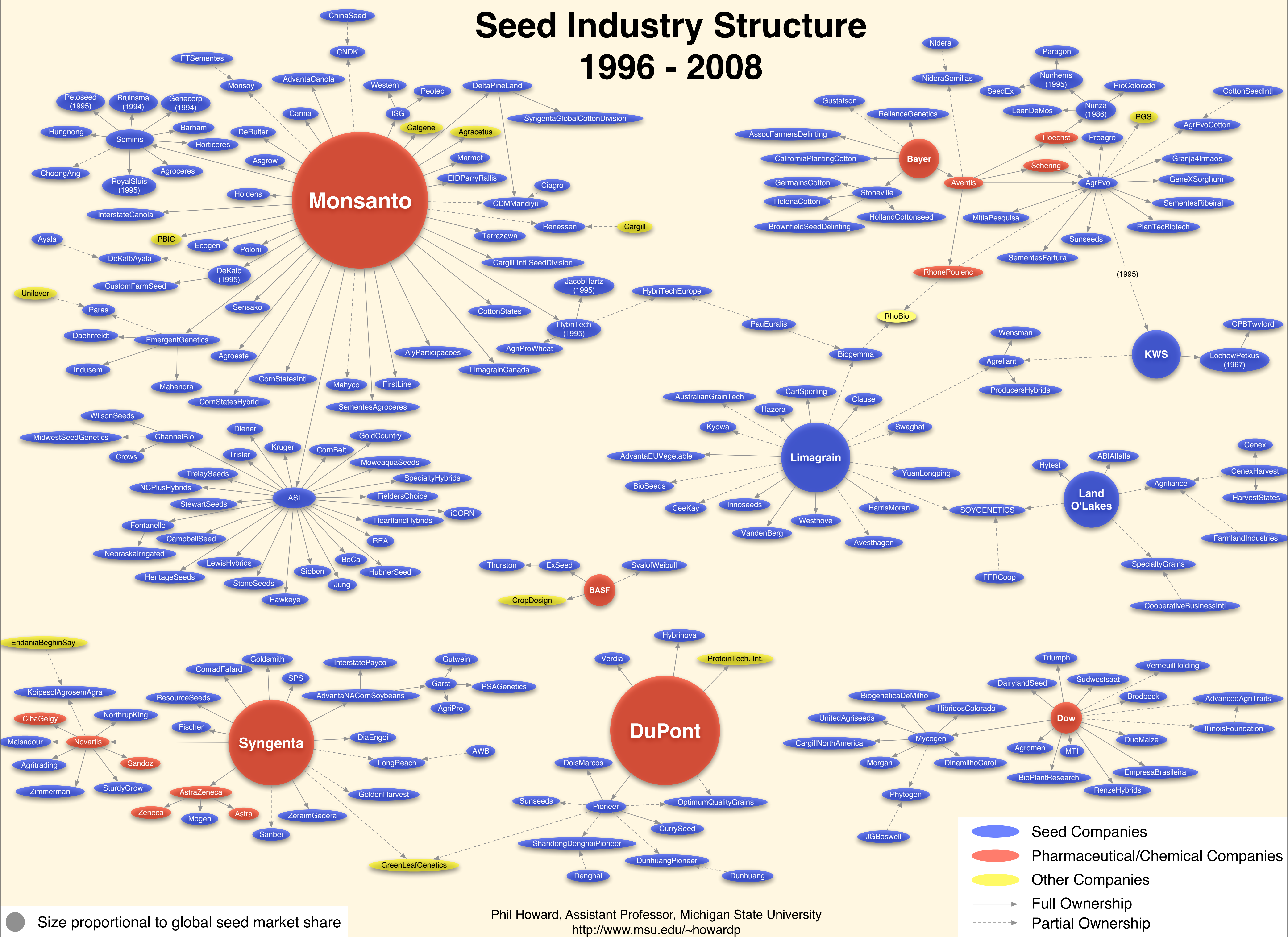
- Cultural Methods
  - Crop Rotation
    - *Vegetables*
    - *Grains & livestock*
  - Drainage
  - Green Manure
    - *Legumes*
    - *Grasses*
  - Minimum Tillage
  - Crop Residues
  - Undersowing

Fertilizers

- Primary Minerals
- Rock phosphate
- lime
- Organic wastes
- Organic Fertilizers
- Blood meal
- Bone meal
- Compost
- Manure
- Commercial inputs


Organic Industry Structure:
Acquisitions by the Top 30 Food Processors in North America
June 2009
Hershey Foods #24
October 2006
Dagoba
Cadbury sold N.A. beverage division in 2008
2002, 5% Equity May 2005, 100% Equity
Green & Black's
M&M Mars #14
1997
Seeds of Change
ConAgra #9
July 2007
Alexia Foods
July 2000
Lightlife
General Mills #7
June 2008
LaraBar
December 1999
Cascadian Farm
March 1998
Muir Glen
Kraft #3
February 2000
Boca Foods
September 2003
Back to Nature
Frutti di Bosco
Millina's Finest
June 2001
Walnut Acres
October 2001
Mountain Sun
ShariAnn's
June 2003
Heinz #27
September 1999 $100 M
19.5% Equity; December 2005 0% Equity
Earth's Best
September 1999 From Heinz
Nile Spice
December 1998
Spectrum Organics
August 2005 $33 M
Garden of Eatin'
DeBole's
Arrowhead Mills
April 1998 $80 M
French Meadow
Rich Products Corp. (#40) January 2007
May 2002
Cargill #20
August 2003
MaraNatha
SunSpire
March 2008
Hain Celestial #85
June 2007 From Dean
TofuTown
Westbrae
Bearitos
Westsoy
Little Bear
October 1997 $23.5 M
March 2000 $390 M
Celestial Seasonings
December 2002
Imagine/Rice Dream/Soy Dream
April 1999 $80 M
Breadshop
Health Valley
Casbah
White Wave/Silk
June 1998 36% Equity May 2002 100% Equity $189 M
Dean #6
May 1999
Alta Dena
July 1998 13% Equity January 2004 100% Equity $216 M
Horizon
April 1999
The Organic Cow of Vermont
Nestle #5
September 2008 $57M via Israeli subsidiary Osen Group (50.1% Equity)
Tribe Mediterranean Foods
Coca-Cola #13
February 2008 40% Equity $43 M
Honest Tea
October 2001 $181 M
Odwalla
Pepsi #2
November 2006
Naked Juice
Kellogg #10
November 2007 $122 M
Bear Naked
Wholesome & Hearty
June 2000
Kashi
November 1999 $307 M
Morningstar Farms/Natural Touch
Food Processors #
Organic Brand Acquisitions
Strategic Alliances
Numbers refer to rank in North American food sales according to Food Processing, August, 2008

Seed Industry Structure
1996 - 2008



Phil Howard, Assistant Professor, Michigan State University
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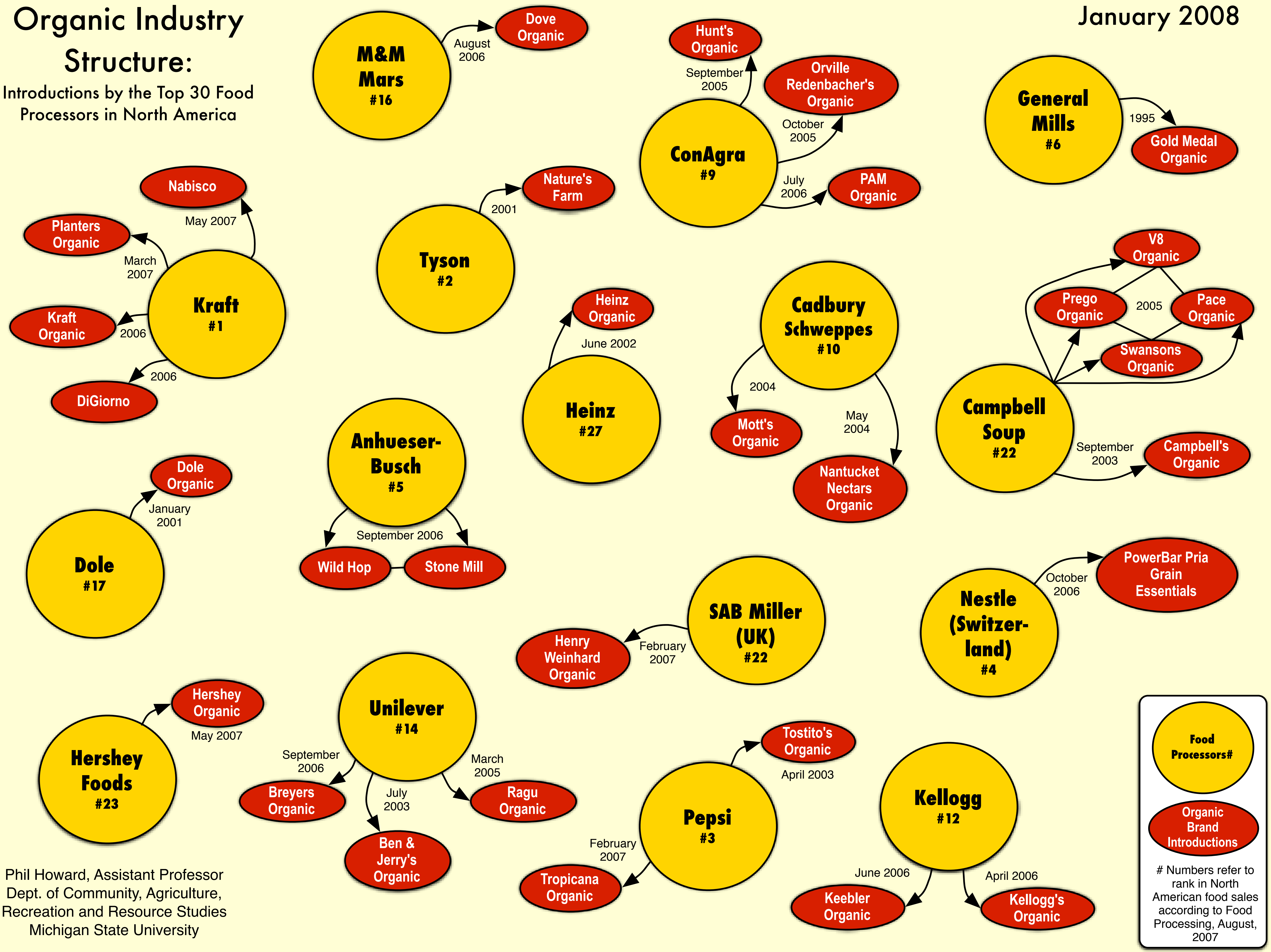
Organic Industry Structure:

Introductions by the Top 30 Food Processors in North America

January 2008



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Permaculture Design

What is Permaculture?

Permaculture: the use of ecology as the basis for designing integrated systems of food production, housing, appropriate technology, and community development.

Permaculture is built upon an ethic of caring for the earth and interacting with the environment in mutually beneficial ways.

Permaculture Drylands Institute, 1989

Permaculture Ethics

- **Care of the Earth**
  - includes all living and non-living things—plants, animals, land, water and air
- **Care of People**
  - promotes self-reliance and community responsibility—access to resources necessary for existence
- **Setting Limits to Population & Consumption**
  - By governing our own needs, we can set resources aside (surplus time, labor, money, information, & energy) and contribute them to achieve the above aims.

Principles of Permaculture

- Observation
    - Observe and Replicate Natural Patterns
- Relationships
    - Each Element Supports Multiple Functions
    - Each Function Is Supported by Many Elements
    - Relative Location-recognize Connections, Diversity
    - Local Focus
    - Stacking

Principles of Permaculture (cont.)

- Resources
  - Resource - Energy Storage
  - Pollution Is an Unused Resource
  - System Yield
  - Using Biological Resources
  - Use Onsite Resources
  - Energy cycling

Principles of Permaculture (cont.)

- Design
  - The Yield of a System Is Theoretically Unlimited
  - Work Within Nature
  - Polyculture and diversity of species
  - Edge Effect - Ecotones
  - Make Least Change For the Greatest Effect
  - Small Scale Intensive Systems
  - Relinquish Power
  - Appropriate Technology

Farming systems and techniques

- Agroforestry
- Swales
- Contour plantings
- Hedgerows and windbreaks
- Pond-dike aquaculture
- Intercropping

Gardening and recycling methods

- Edible landscaping
- Keyhole gardening
- Companion planting
- Trellising, sheet mulching
- Chicken tractors
- Solar greenhouses
- Spiral herb gardens
- Vermicomposting

Principles for Functional Design

- **Observe**. Use protracted and thoughtful observation rather than prolonged and thoughtless action. Observe the site and its elements in all seasons. Design for specific sites, clients, and climates.
- **Connect**. Situate elements to create more useful relationships and time-saving connections among all parts. Increasing connections among elements creates a healthier, more diverse ecosystem.
- **Catch and store**. Identify, collect, and hold the useful flows of energy and materials moving through the site. By saving and re-investing resources, we maintain the system and capture still more resources.
- **Stack Functions**. Choose and situate each element in a system to perform multiple functions. Increasing beneficial connections between components stabilizes systems. Stack elements in space and time.
- **Build Redundancy**. Use multiple methods to achieve important functions and to create synergies. Redundancy protects when one or more elements fail.
- **Least Change, Max Effect**. Find the "leverage points" in the system and intervene there, where the least work accomplishes the most.
- **Intensify Small Scale Systems**. Start at your doorstep with the smallest systems that will do the job, and build on your successes, with variations.

Principles for Living and Energy Systems

- **Edge Effect**. The edge—the intersection of two environments—is the most diverse place in a system, and is where energies and materials accumulate. Optimize the amount of edge.
- **Accelerate Ecological Succession**. Mature ecosystems are more diverse and productive than young ones, so use design to jump-start succession.
- **Biological and Renewable Resources**. Renewable resources (usually plants and animals) reproduce and build up over time, store energy, assist yield, and interact with other elements.
- **Recycle Energy**. Supply local and on-site needs with energy from the system, and reuse this energy as many times as possible. Every cycle is an opportunity for yield.

Attitudes

- **Problems to Solutions.** Challenges and constraints can inspire creative design. "We are surrounded by insurmountable opportunities."
- **Get Yield.** Get both immediate and long-term returns from your efforts: "You can't work on an empty stomach." Set up positive feedback loops to build the system and repay your investment.
- **Unlimited Yields.** The biggest limit to the total yield of a system is the designer's imagination.
- **Disperse Over Time.** Using the Principle of Seven Generations, we can use energy to construct systems, if they store or conserve more energy during their lifecycles than we used to construct or maintain them.
- **Mistakes Teach.** Evaluate your trials and learn from your results. Making mistakes is a sign you're trying to do things better.

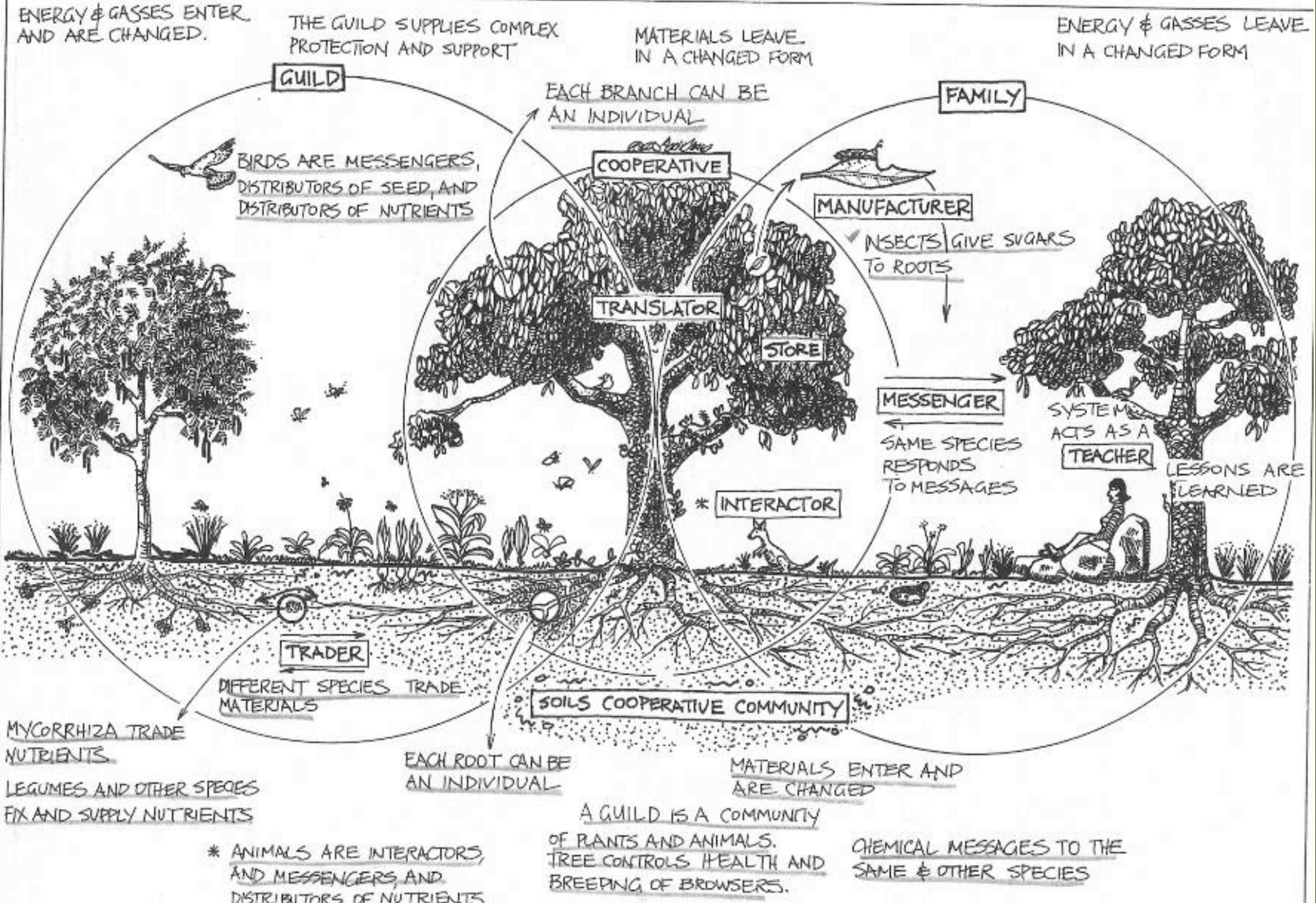
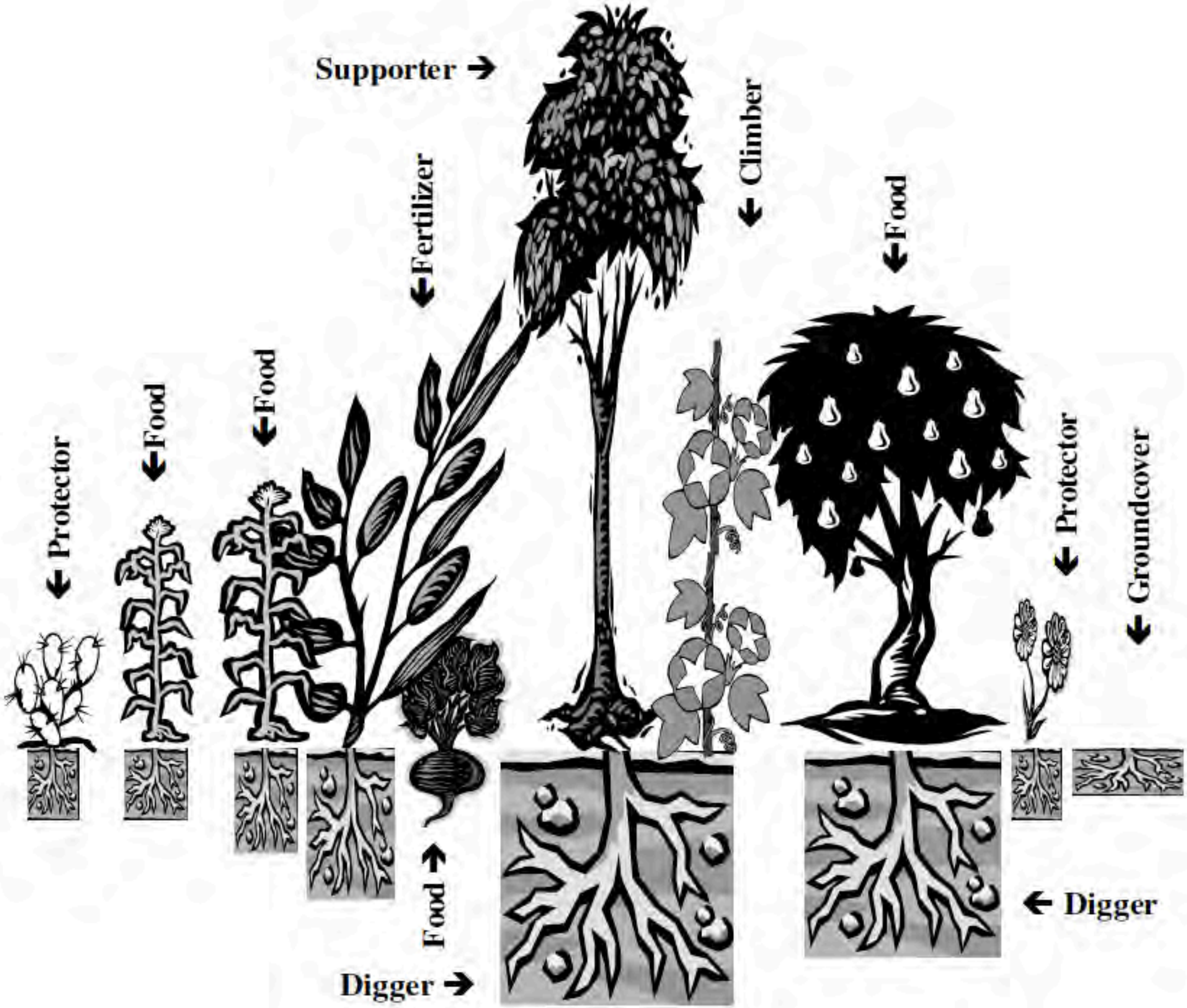


FIGURE 6.1
TREES IN A WHOLE SYSTEM
The tree itself is a cooperative, depends on a guild, is a member of a family of like species, and is involved in the creation of complex molecules from inorganic and organic elements – a transformer, or translator, of gases, liquids, and solids.

Permaculture Guilds

The following is a list of seven different functions that a Permaculture guild tries to include:

1. Food	Staples, legumes, fruits, vegetables, and fats
2. Food for the soil	Legumes and organic matter that provide nutrients to the soil
3. Climbers	Important for making the most of vertical space
4. Supporters	Plants that provide support to climbers
5. Miners or diggers	Deep roots or tubers that open the soil and bring up nutrients from deep
6. Groundcovers	Protects soil, provides shade, holds moisture, and suppresses weeds
7. Protectors	Protection for others in the system (Repellents, attractors, live fencing, etc.)

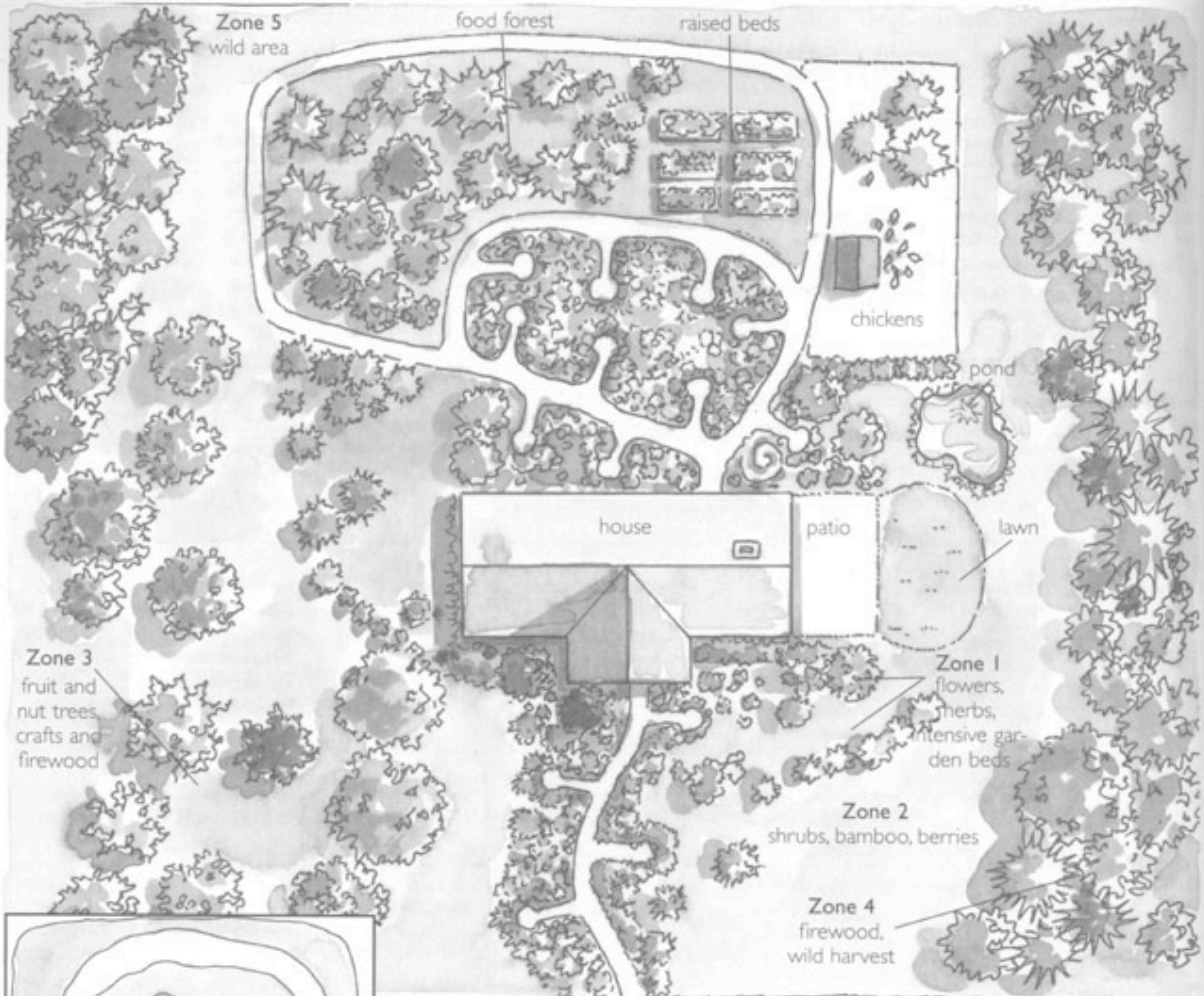

Supporter
Fertilizer
Climber
Food
Protector
Food
Food
Protector
Groundcover
Food
Digger
Digger

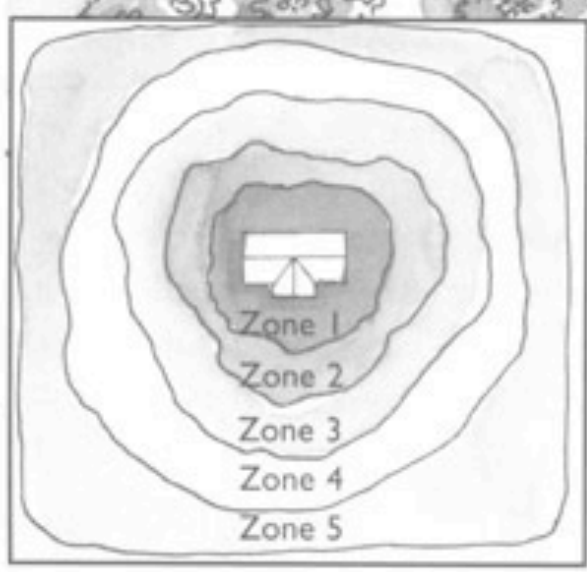
Example: Chicken tractor

Joe Salatin's Chicken Tractor

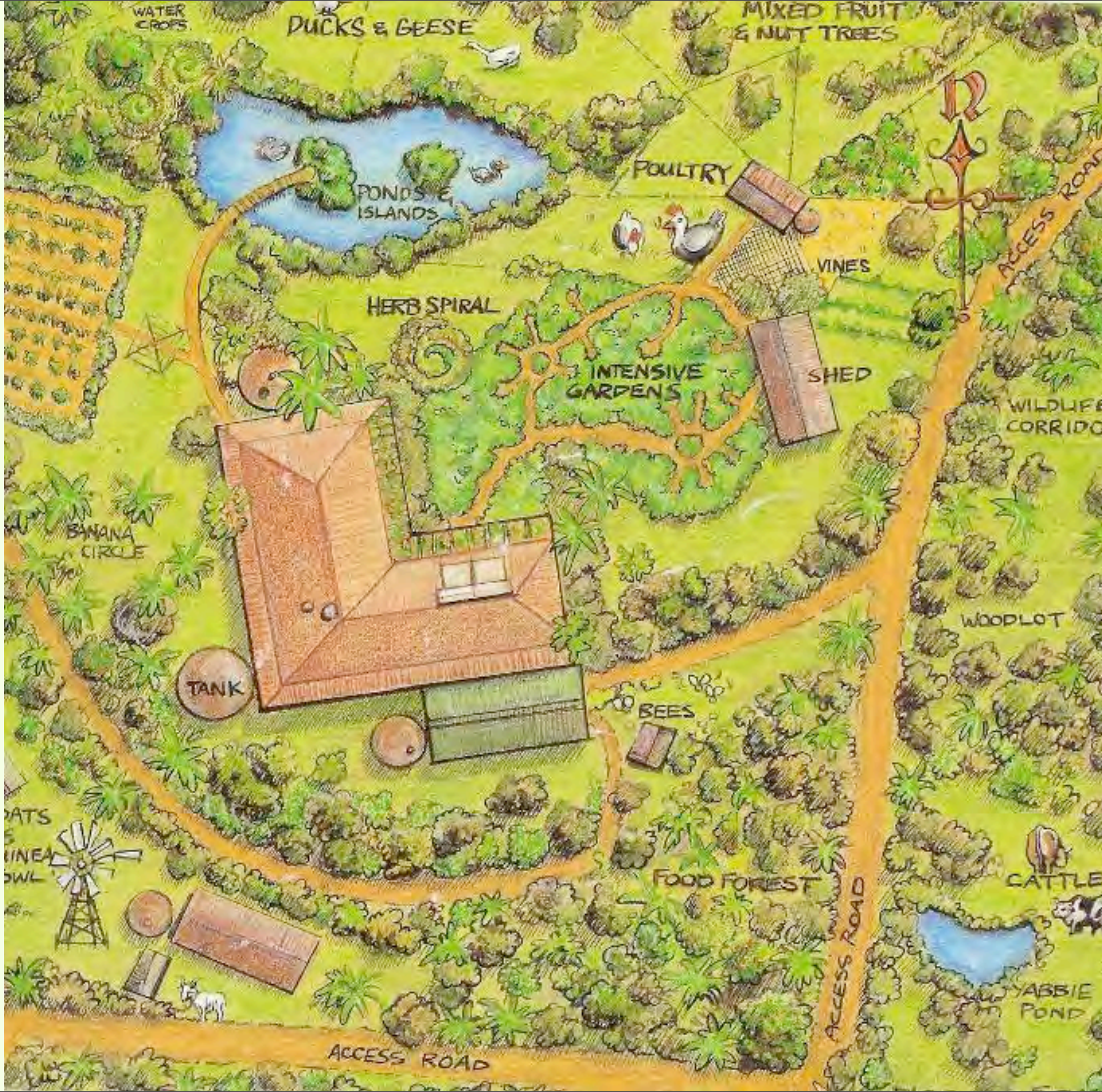
- Chickens in movable coop (move as desired)
- Chickens perform basic chicken functions: scratch, eat bugs, weeds, deposit manure, ect
- Needs supplemental food and water
- Supplies Eggs, Meat, Feathers, etc & Tractor Functions.

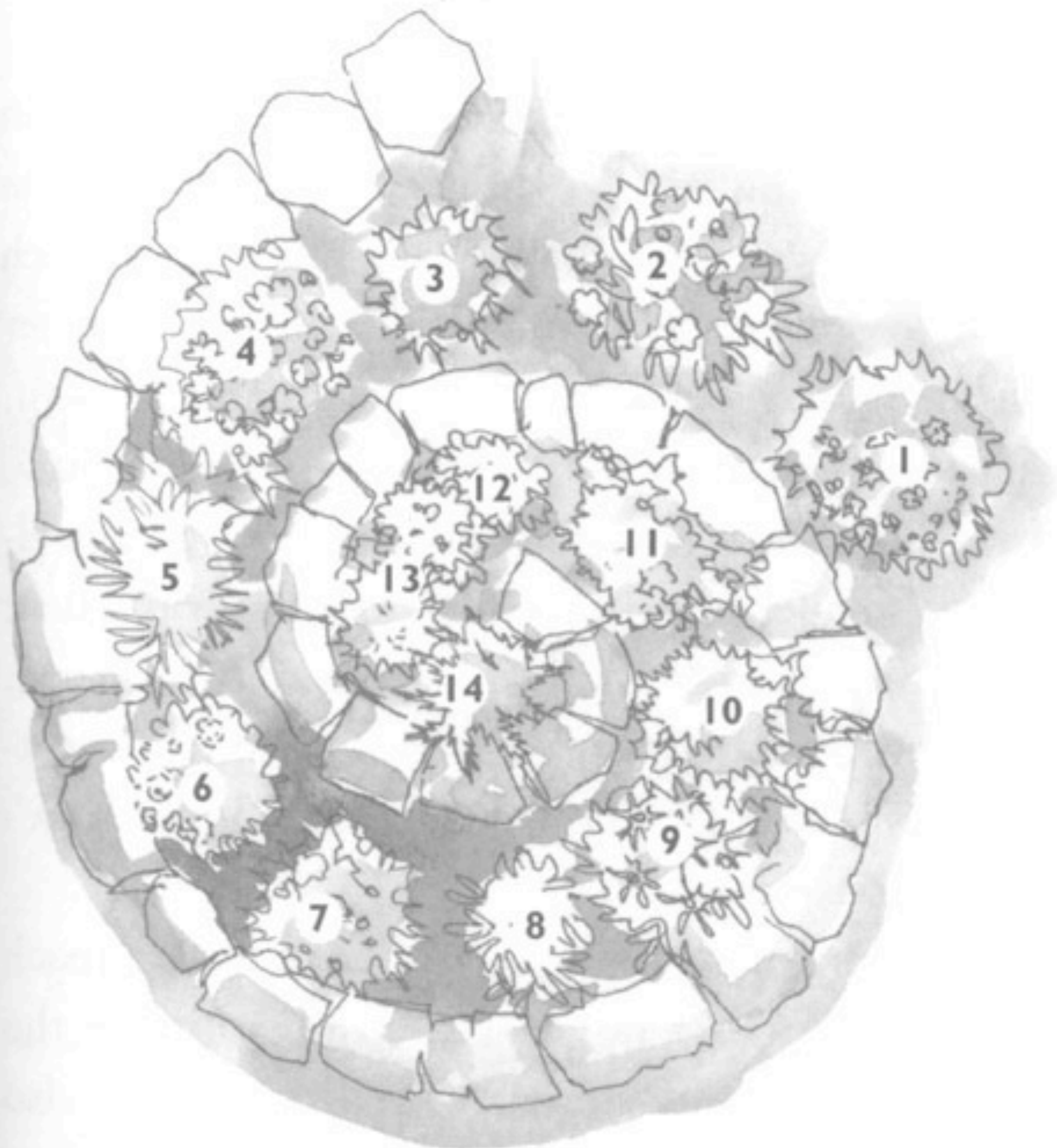
- Each component in a system performs multiple functions, and each function is supported by many elements.
- Example: Chicken greenhouse
  - Chicken coop heats greenhouse
  - Chicken pecking clears land for crops
  - Manure fertilizes soil
  - Feathers used as mulch
-



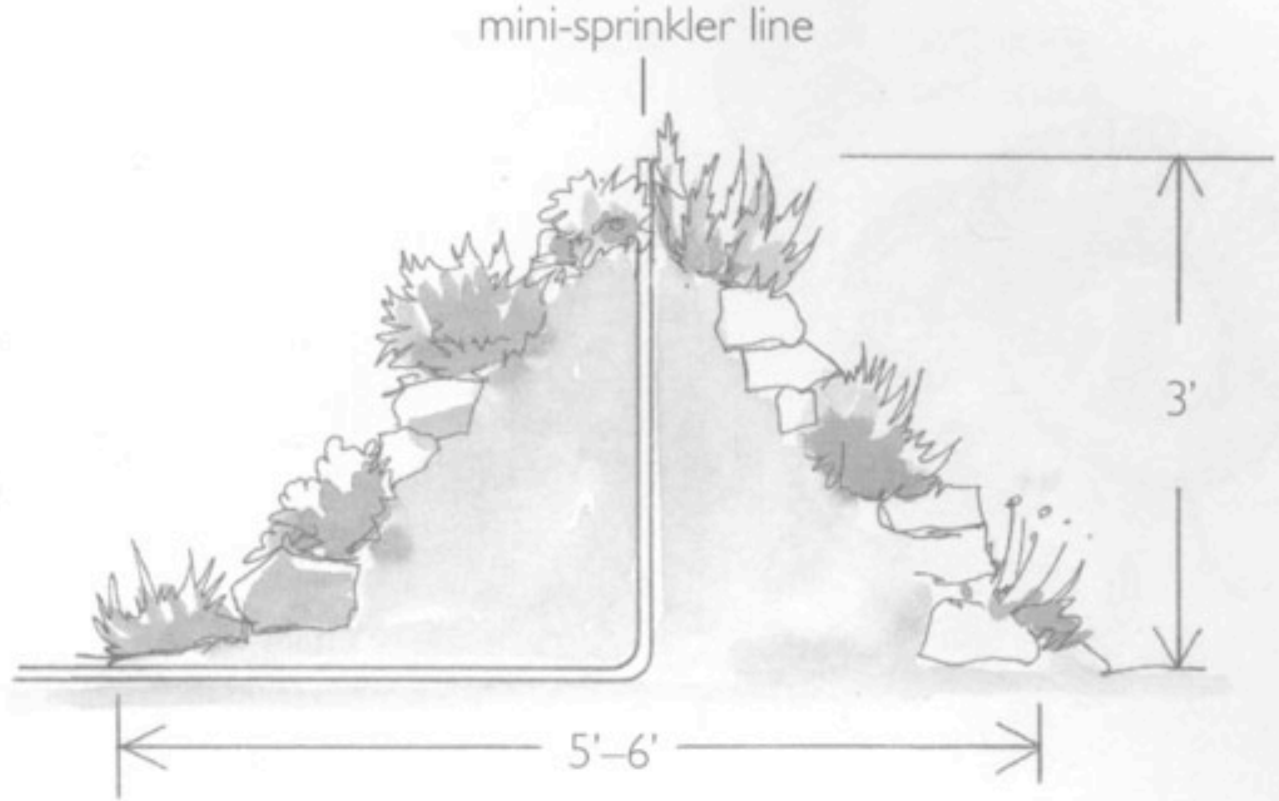


A typical zone layout for a ¼-acre suburban lot. Salad greens, herbs, dwarf fruit trees, patio, lawn, and other often-used items are in Zone 1. Row crops, berries, useful shrubs, a pond, chickens, and a food forest are in Zone 2. Zone 3 holds larger fruit and nut trees, while Zone 4 is for foraging and firewood. A corner of the yard is left wild for Zone 5. The inset drawing shows an idealized pattern, from most-often used to least, of concentric zones around a house.


WATER CROPS
DUCKS & GEESE
MIXED FRUIT & NUT TREES
PONDS & ISLANDS
POULTRY
VINES
HERB SPIRAL
INTENSIVE GARDENS
SHED
ACCESS ROAD
WILDLIFE CORRIDO
BANANA CIRCLE
WOODLOT
TANK
BEES
ATS
INEA
WL
FOOD FOREST
CATTLE
ACCESS ROAD
YABBIE POND
ACCESS ROAD

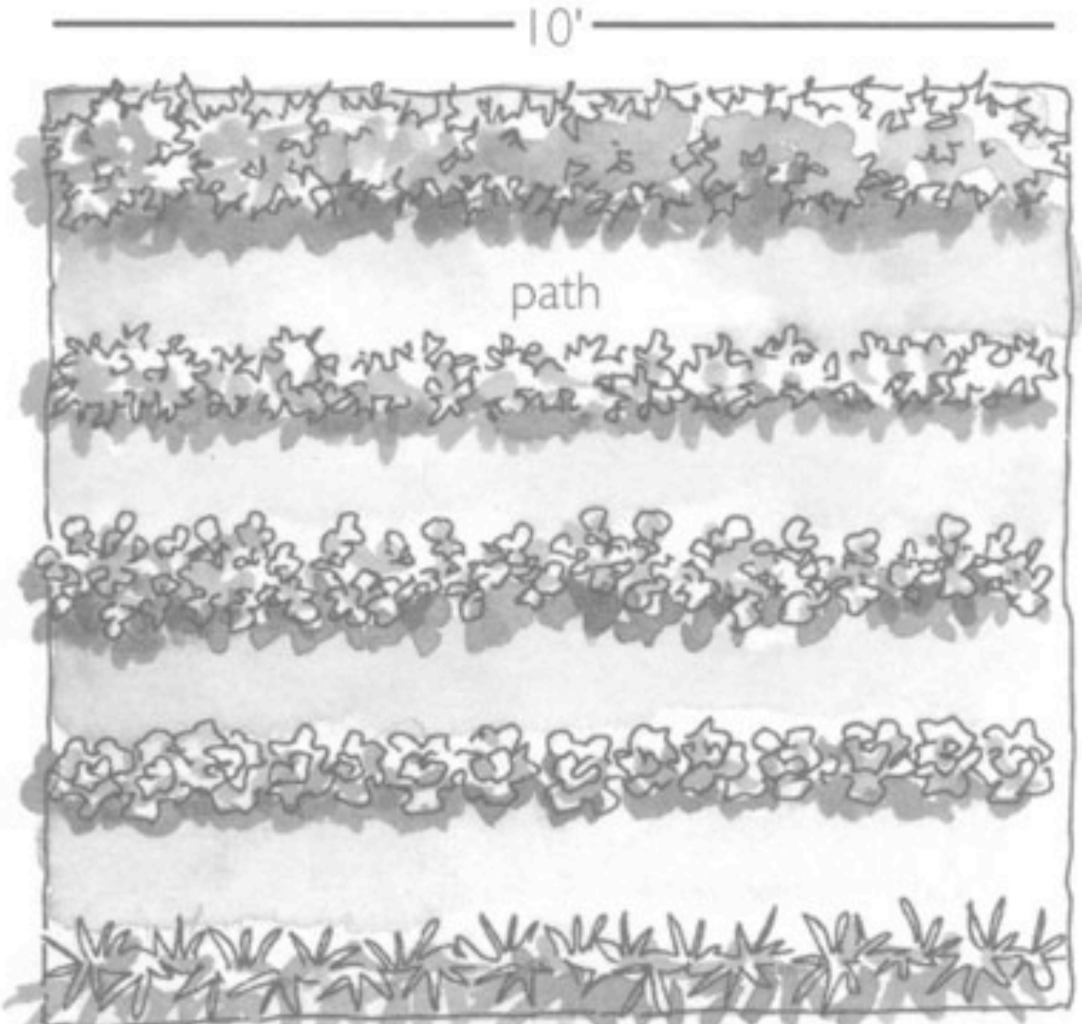


1	feverfew	6	fennel	11	thyme
2	calendula	7	yarrow	12	oregano
3	coriander	8	sage	13	dill
4	parsley	9	echinacea	14	rosemary
5	chives	10	chamomile		



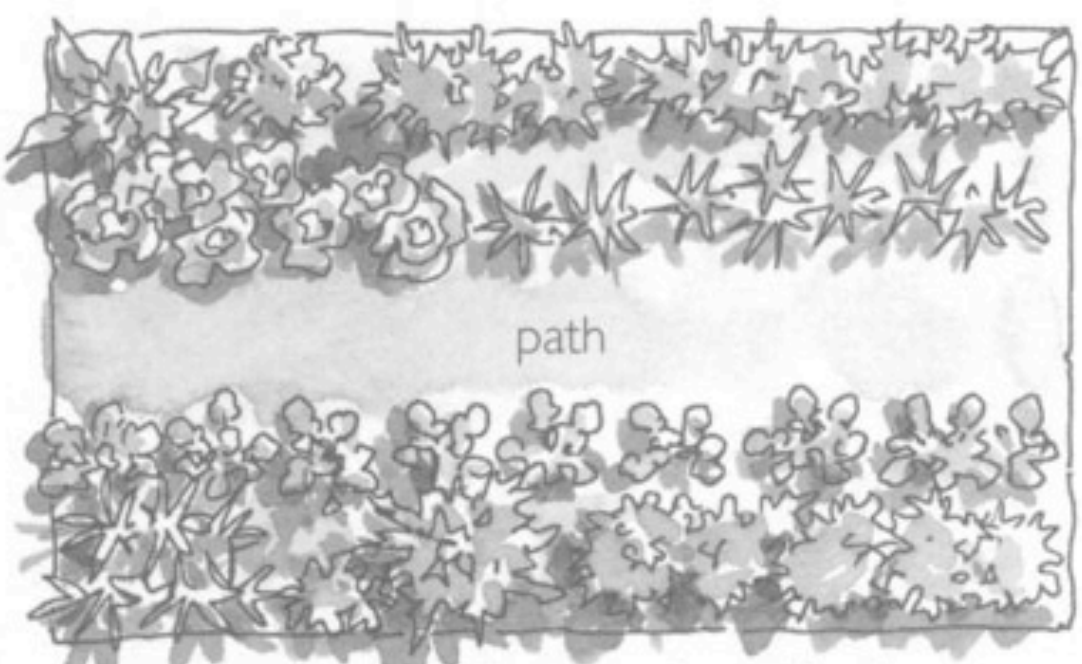
cross section

An herb spiral combines a two-dimensional pattern (a spiral) with a three-dimensional one (a mound) to form a beautiful and space-saving living sculpture that has several microclimates.



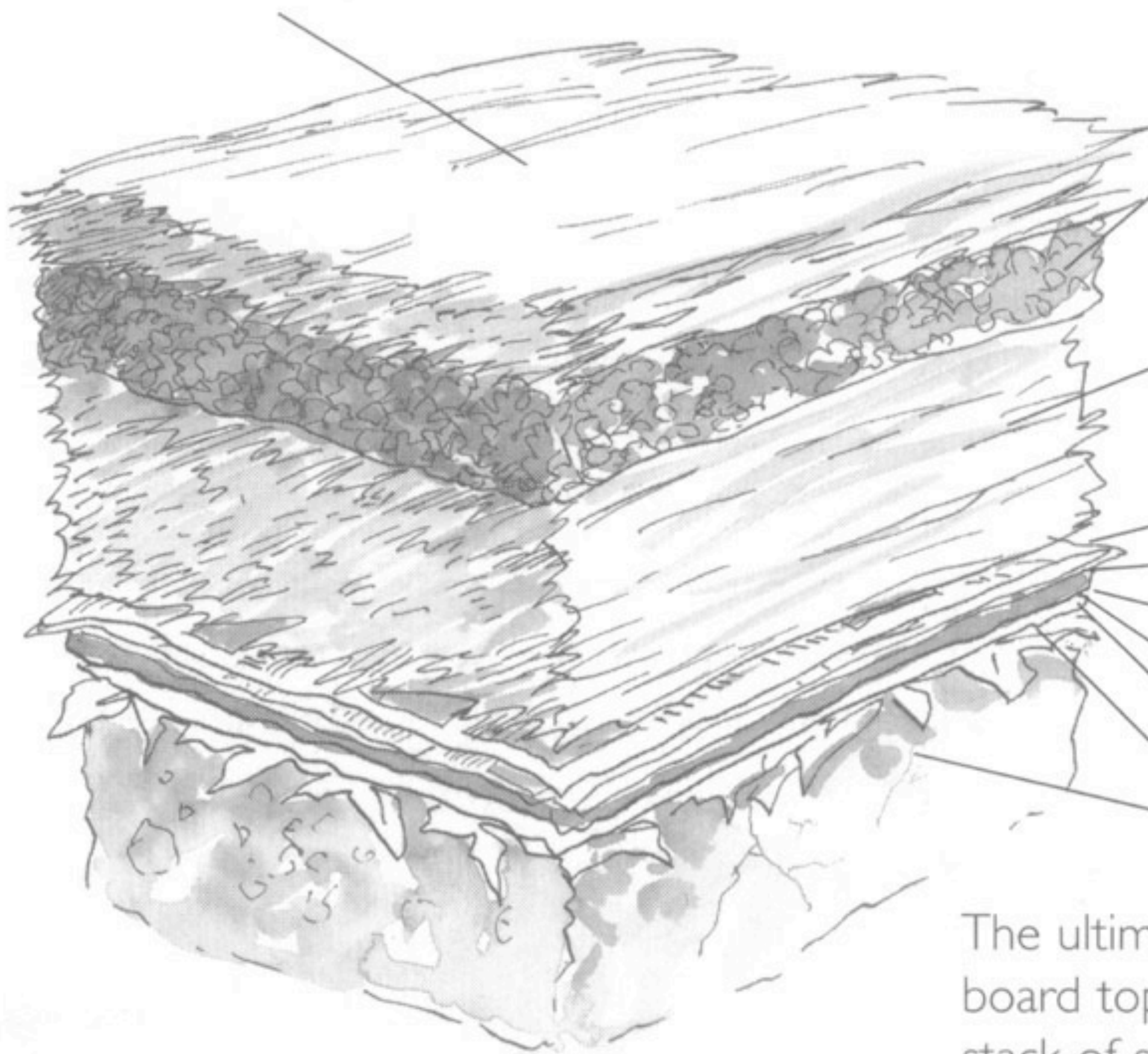
Single rows need 40 square feet of path.

A keyhole bed needs only 6 square feet of path.



Raised beds need 10 square feet of path.

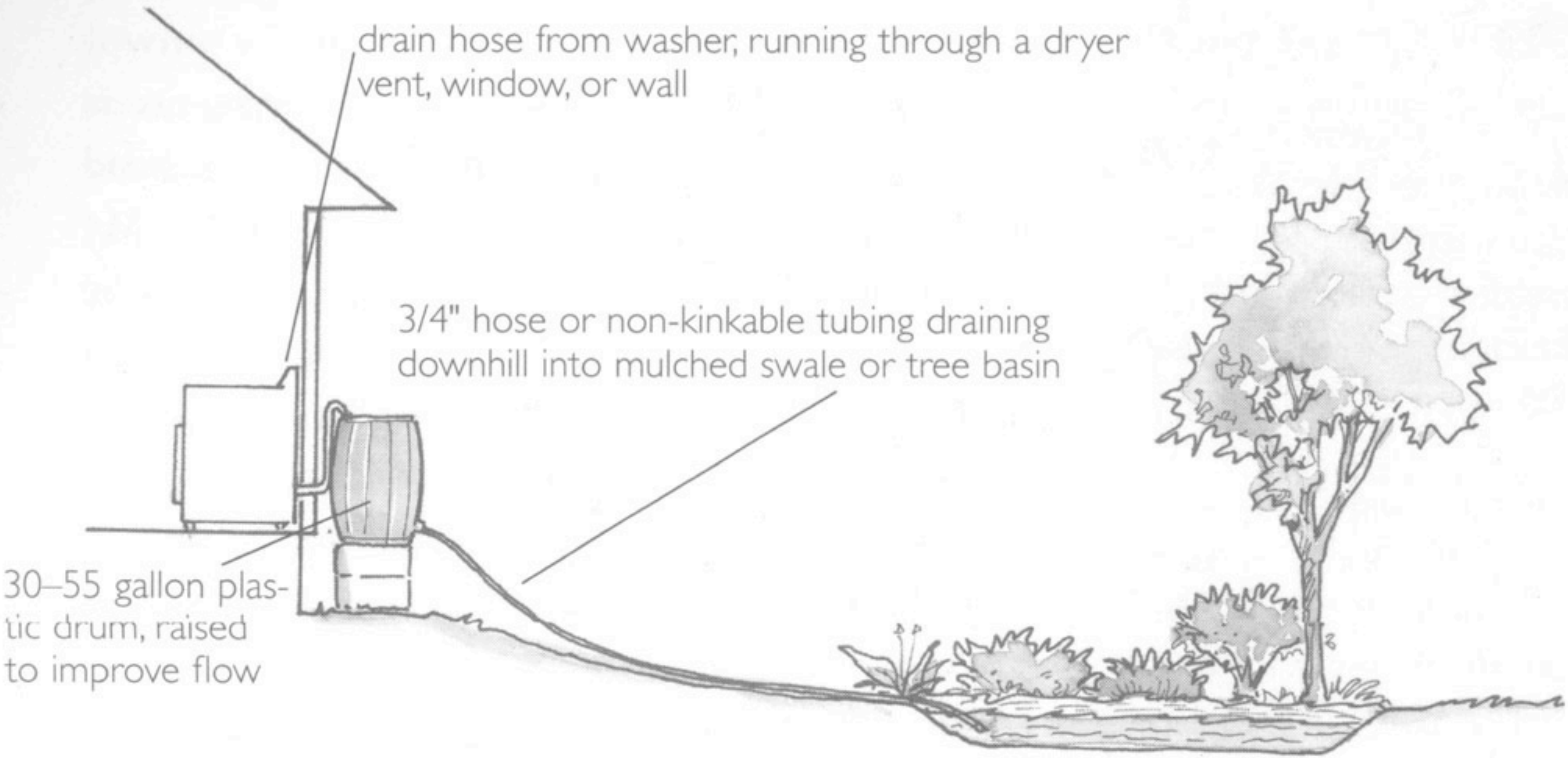
Changing the shape of a garden bed—working with patterns—can reduce the area lost to paths as seen in these beds, each containing 50 square feet of planting.



The ultimate sheet mulch. Sheet mulch can be as simple as cardboard topped with a foot of straw, or it can be a more elaborate stack of soil-building layers, as shown here.

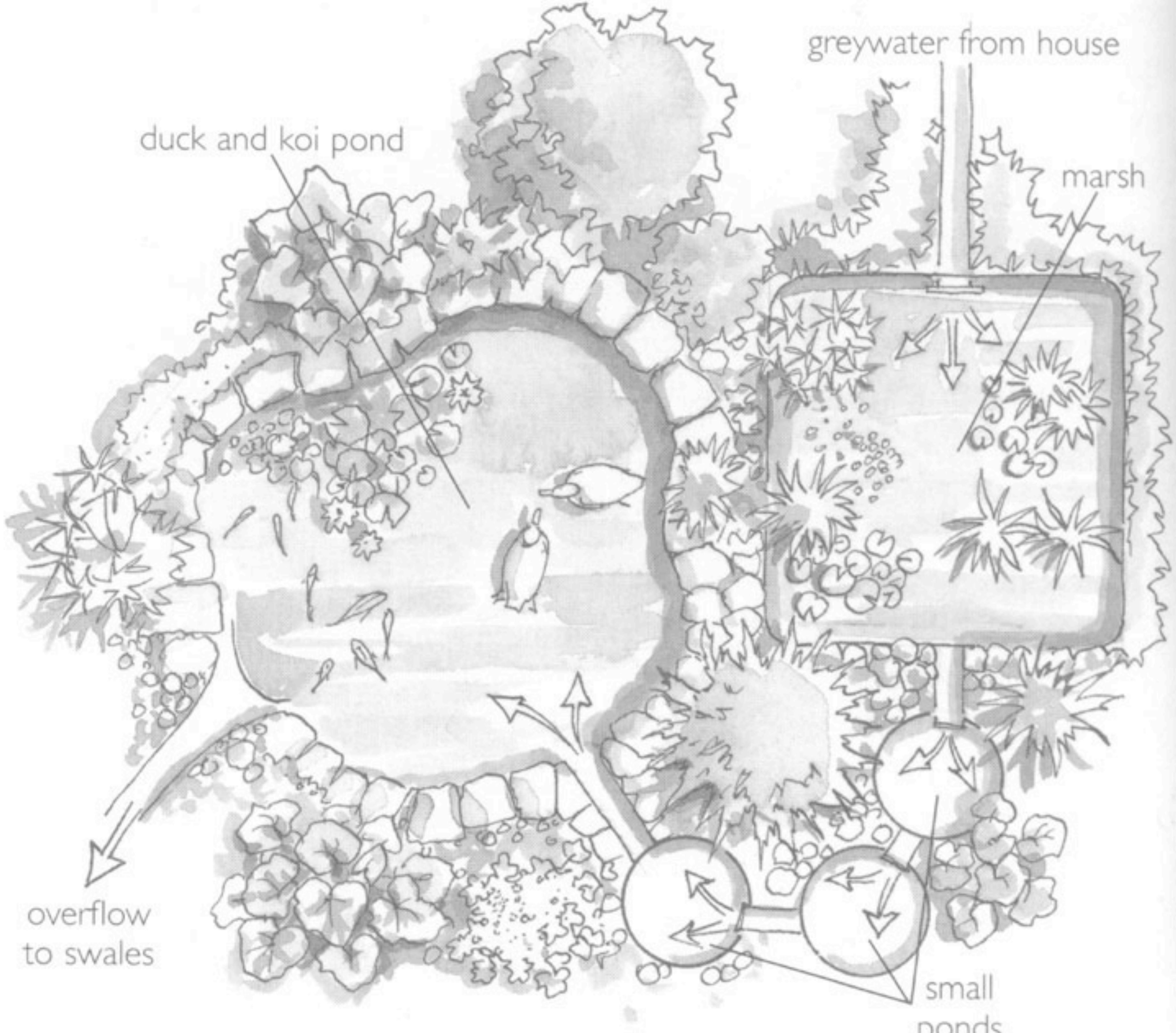
Water collection, management, and re-use systems

- Keyline
- Greywater
- Rain catchment
- Constructed wetlands
- Solar aquatic ponds (also known as living machines).



A washing machine set up to pump greywater into a drum that will then drain to a planted, mulched swale or tree.

Redrawn with permission from Create an Oasis with Greywater, *by Art Ludwig (Oasis Design 2000).*



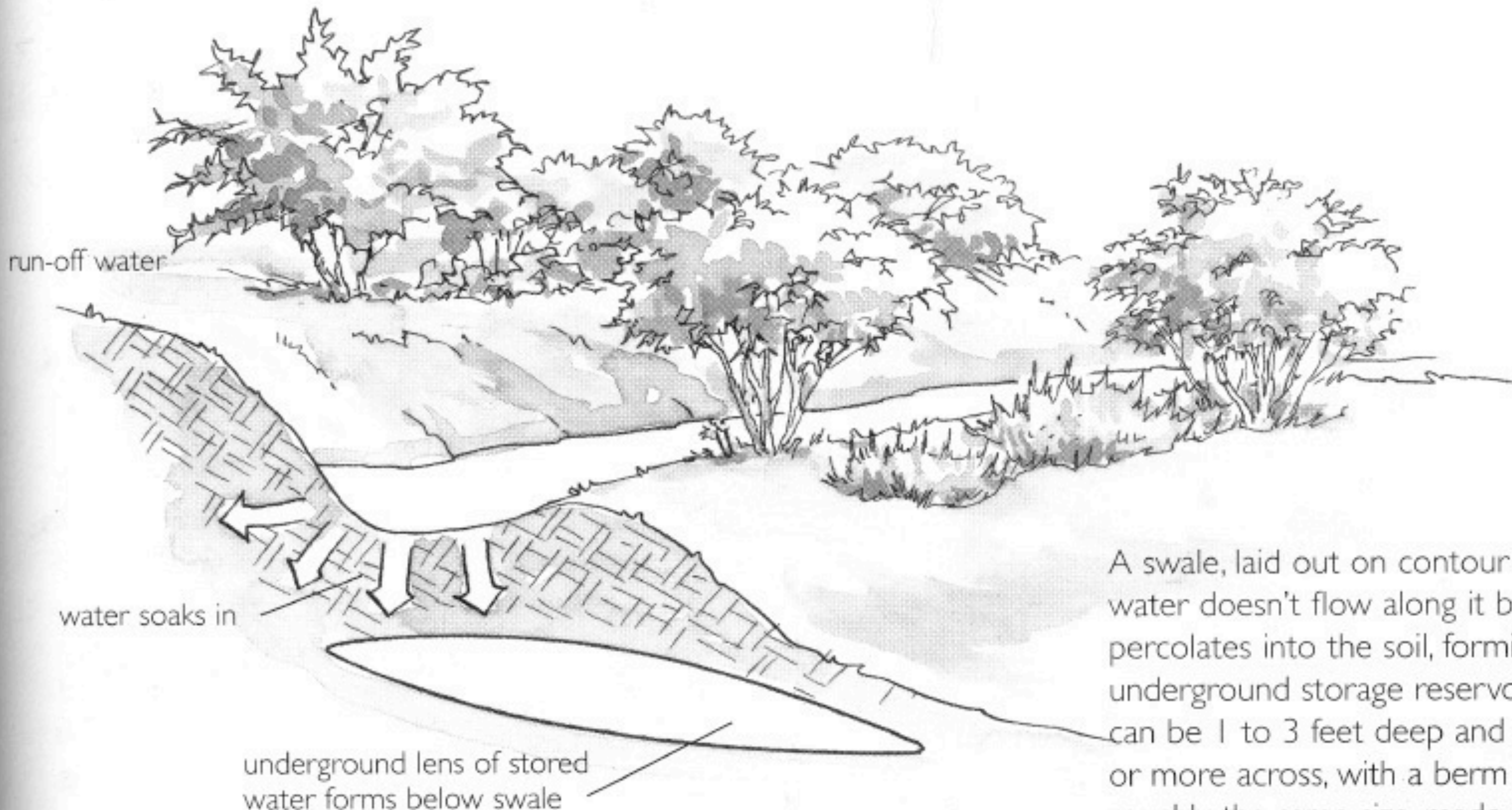
Penny Livingston's greywater marsh and ponds.

Appropriate Technologies

- Solar & Wind Power
- Composting Toilets
- Energy Efficient Housing, Buildings

Trees & Their Energy Transactions

- Biomass
- Wind Effects
- Temperature Effects
- Trees & Precipitation
  - Compression & Turbulence of the Air Stream
  - Condensation Phenomena
  - Rehumidification of Airstreams
  - Effects on Show and Meltwater



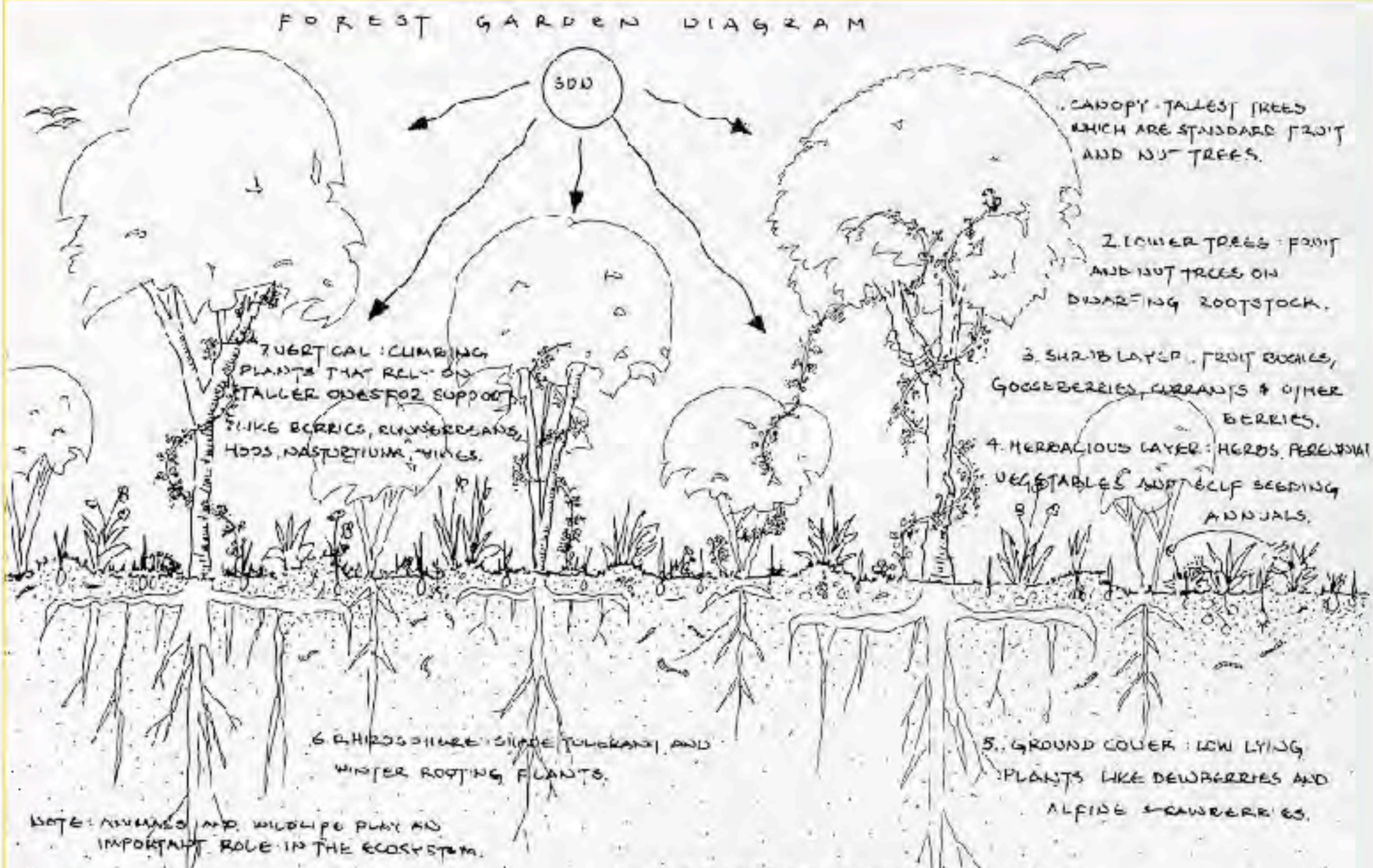
A swale, laid out on contour so that water doesn't flow along it but instead percolates into the soil, forming an underground storage reservoir. Swales can be 1 to 3 feet deep and 1 to 4 feet or more across, with a berm downslope roughly the same size, made from the soil from the swale.

Functional Plant Groups

- Mulch makers
- Nutrient accumulators
- Nitrogen fixers
- Soil fumigants & pest repellents
- Insectary plants
- Soil builders
- Windbreak plants

Forest Garden

- Canopy Layer-tall Trees
- Low-tree Layer
- Shrub Layer
- Herb Layer
- Ground Cover Layer
- Vine Layer
- Root Layer



Ecological & Energy Efficient Designs: Gale & Snowden

Agroforestry

Conservation Agriculture with *Faidherbia albida* – Pathway to Sustainable Maize Production in Central and Southern Africa

Faidherbia is indigenous in many African countries

60 years of research shows on each hectare, mature trees supply the equivalent of 300kg of complete fertilizer and 250kg of lime. This can sustain a maize yield of 4 tons/ha

Comparison of maize and other crops grown under and outside the canopy of Faidherbia in Zambia. Note the dramatic difference in maize growth, February 2009

Biodynamic

- The principles of biodynamic agriculture are derived from Rudolf Steiner (1861–1925) and his spiritual philosophy known as ‘anthroposophy’
- The approach is based on integrating observations of natural phenomena with knowledge of the spirit.

Biodynamic

- Organic farming with a spiritual world view
- Considers the farm as an organism
- Relies of herbal and mineral preparations ex fill cow horn with manure and bury it in the ground
- Uses an astronomical calendar ex. Planting according to phases of the moon

Biodynamic Preparations BD 500-507

Number of preparation	Main ingredient1	Use	Mentioned in connection with:
BD 500	Cow manure	Field spray	Soil biological activity
BD 501	Ground Silica from quartz	Field spray	Plant resilience
BD 502	Yarrow flowers (*Achillea millefolium L.*)	Compost preparation/inoculant	K and S processes
BD 503	Chamomile flowers *(Matricaria recutita L.*)	Compost preparation/inoculant	Ca and K processes
BD 504	Stinging nettle shoots (*Urtica dioica L.*)	Compost preparation/inoculant	N management
BD 505	Oak bark (*Quercus robur L.*)	Compost preparation/inoculant	Ca processes
BD 506	Dandelion flowers (*Taraxacum officinale Web*.)	Compost preparation/inoculant	Si management
BD 507	Valerian extract (*Valeriana officinalis L.*)	Field spray, compost preparation/inoculant	P and warmth processes
BD 508	Horsetail (*Equisetum arvense L.*)	Field spary	

Liquid Manures

NUTRIENTS THAT ARE AVAILABLE IN DIFFERENT PLANTS

Blackberry: iron ▪ Borage: potassium ▪ Bracken fern: potassium ▪ Broom: magnesium, sulphur ▪ Buttercup: cobalt ▪ Cabbage leaves: sulphur ▪ Chickweed: phosphorus, boron, zinc, iron, calcium, magnesium, manganese, silicon ▪ Comfrey: phosphorus, calcium, potassium, iron, sodium, manganese, chromium, selenium ▪ Dandelion: calcium, copper, iron, magnesium, potassium, silicon ▪ Fennel: copper, potassium, sodium, sulphur ▪ Inkweed (phytolacca): potassium ▪ Lucerne: potassium, nitrogen, phosphorus ▪ Petty spurge: boron ▪ Ragwort: copper ▪ Stinging Nettle: iron, potassium, sodium, sulphur, calcium, selenium, chromium, silicon, cobalt, zinc, magnesium, manganese ▪ Thistles: nitrogen, copper, silicon ▪ Willow: calcium ▪ Yarrow: potassium

Organic and Biodynamic Management: Effects on Soil Biology

L. Carpenter-Boggs,* A. C. Kennedy, and J. P. Reganold

Table 5. Soil microbial biomass, activity, and substrate measurements in plot soils (0–15 cm depth) in eastern Washington in 1995 after one cropping season under management varying by fertilizer type and application of biodynamic (BD) field sprays.

Treatment	Dehydrogenase activity	Microbial biomass (SIR)	Basal soil respiration	10-d mineralized C (MinC)	qCO_2	SIR/MinC
	μg TF g^{-1} soil h^{-1}	μg C_{mic} g^{-1} soil	μL CO_2 g^{-1} soil h^{-1}	μg C_{avail} g^{-1} soil	mg CO_2–C g^{-1} C_{mic} h^{-1}	μg C_{mic} μg^{-1} C_{avail}
Fertilizer						
BD compost	3.54a*	418	19.0	89.62a*	22.4	4.66
Non-BD compost	3.65a	418	16.2	95.74a	19.1	4.37
Mineral fertilizers	3.06b	368	10.1	55.51b	13.5	6.63
None	3.07b	351	10.3	65.08b	14.4	5.39
BD sprays						
Yes	3.27	402	13.9	79.32a*	17.0	5.04
No	3.39	375	13.9	73.66b	17.7	5.49
			P value			
Statistical contrasts†						
Compost vs. no compost	0.001	NS	0.06	0.001	NS	NS
Compost vs. mineral	0.001	NS	NS	0.001	NS	0.06
Organic vs. biodynamic	NS	NS	NS	NS	NS	NS

* Means with different letters are significantly different $\alpha = 0.05$.

† Compost vs. no compost, all plots receiving BD or non-BD compost vs. all plots not receiving compost; compost vs. mineral, all plots receiving BD or non-BD compost vs. all plots receiving mineral fertilizers; organic vs. biodynamic, plots receiving non-BD compost and no BD sprays vs. plots receiving BD compost and BD sprays.

Table 1. The main characteristics of long-term trials, which are based on sound scientific methods and include BD research.

Country of trial	Trial description	Duration of trial	Size of experimental plots	Crop rotation and fertilization	References
Therwil, Switzerland	In the DOK trial biodynamic, organic, conventional farmyard manure and conventional-mineral farming systems are compared with control plots	1978–the present	10 m × 10 m	Crop rotation same in all systems 2 fertilizing intensities (0.7 and 1.4 livestock units) FYM[1], composted FYM[1] with added BD[3] preparations and MIN[2] are used, depending on production system	Pfiffner and Mäder[19]; Mäder et al.[13]; Fließbach et al.[14]
Darmstadt, Germany	With the MIN–ORG trial, maintained at the Institute for Biodynamic Research, the question of mineral versus organic fertilizers is tackled	1980–the present	5 m × 5 m	Same crop rotation and similar soil tillage are used in all treatments Nitrogen (N) input levels are maintained at the same level, whereas MIN[2], FYM[1] and composted FYM[1] with added BD[3] preparations are used to supply N to the soil	Raupp[22]
Bonn, Germany	Effects of traditionally composted FYM[1] against two types of BD[3] composted FYM[1] and a control plot were investigated	1993–2001	6 m × 10 m	Same 6-year crop rotation with similar land-management techniques was used FYM[1] and composted FYM[1] with added BD[3] preparations were used as fertilizers at a rate of 30 t ha^{-1}	Zaller and Köpke[16]
Therwil, Switzerland	Three-factorial experiment with BD[3] preparations, soil tillage and fertilization as investigated factors	2002–the present	12 m × 12 m	Same crop rotation in all treatments FYM[1] or slurry is applied to crops at an intensity of 1.4 livestock units	Berner et al.[50]

[1] FYM – farmyard manure.
[2] MIN – mineral fertilizers.
[3] BD – biodynamic.

Biodynamic Comparison Studies

Table 3. Yield comparison of some crops under different agricultural production systems.

Treatments	Wheat yield			Potato yield			Rye yield			Grass–clover yield			Source
	CON[1]	ORG[2]	BD[3]	CON[1]	ORG[2]	BD[3]	CON[1]	ORG[2]	BD[3]	CON[1]	ORG[2]	BD[3]	
	110	99	100	154	102	100	n/a	n/a	n/a	125	92	100	Mäder et al.[13]
	n/a	99	100	n/a	101	100	n/a	100	100	n/a	91	100	Zaller and Köpke[16]
	104	99	100	103	94	100	126	94	100	n/a	n/a	n/a	Raupp[22]
	n/a	No difference		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Berner et al.[50]
Average	107	99	100	128.5	97.5	100	126	97	100	125	91.5	100	

Yield relative to BD = 100.
n/a – no data available.
[1] CON – conventional or mineral treatments.
[2] ORG – organic treatments.
[3] BD – biodynamic treatments.

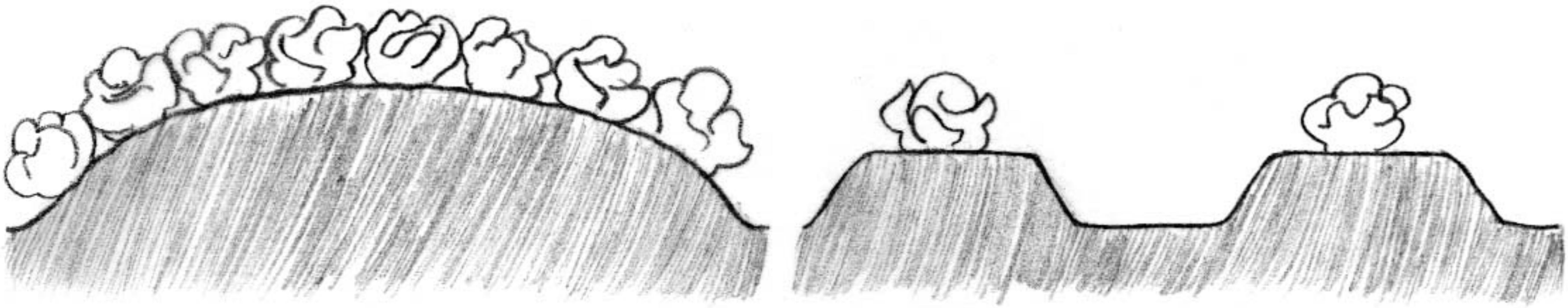
Table 4. Soil organic matter carbon (C_{org}) change, microbial biomass carbon (C_{mic}) content and dehydrogenase activity depending on the production system.

Trial site soil	Sampling depth (cm)	Soil C_{org} beginning (%)	Soil C_{org} change over the trial period (soil C_{org} beginning = 100)			Soil C_{mic} content (CON or MIN = 100)			Dehydrogenase activity (†µg TPF 10 g^{-1}; ‡µg TPF g^{-1}h^{-1})			Source:
			CON[1]/MIN[2]	ORG[3]	BD[4]	CON[1]/MIN[2]	ORG[3]	BD[4]	CON[1]/MIN[2]	ORG[3]	BD[4]	
Haplic luvisol	0–20	1.42–1.51	85/n/a	91	101	100/81	117	134	132/87‡	175‡	226‡	Fließbach et al.,[14]
Fluvisol	0–20	n/a	n/a	n/a	n/a	100/n/a	125	125	88†	130†	130†	Zaller and Köpke, 2004[5]
Sandy orthic luvisol	0–25	1.05	n/a/79	91	100	n/a/100	114	126	75.9†	109.1†	121.9†	Raupp[22]

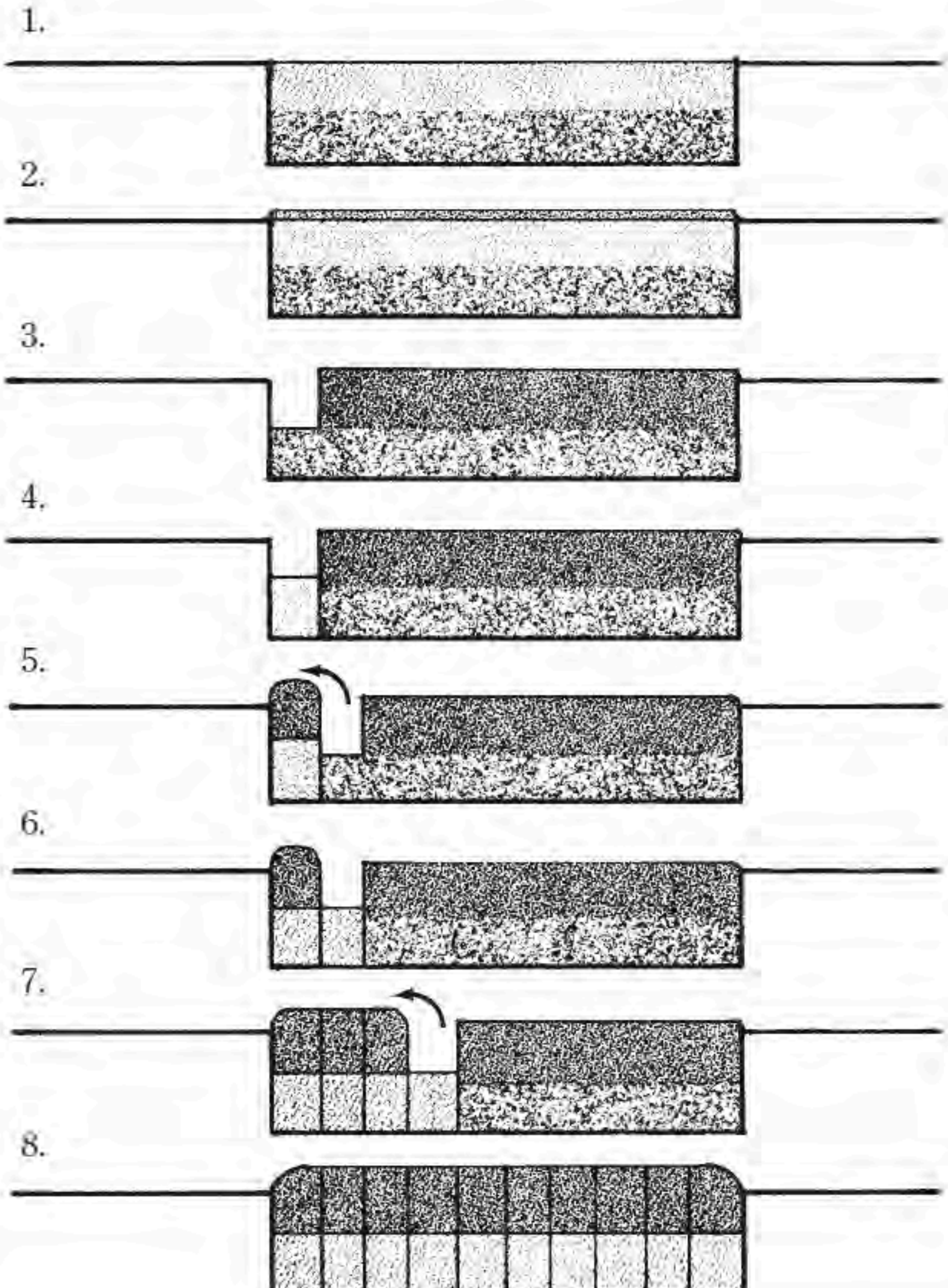
n/a – no data available/non-applicable.
[1] CON – conventional or control treatments.
[2] MIN – mineral treatments.
[3] ORG – organic treatments.
[4] BD – biodynamic treatments.
[5] Estimates are given from figures.
‡,† Note that results are given in different units; TPF, triphenylformazan.

Bio-Intensive Farming

- Deep soil preparation
  - maintained for several years with 2-inch-deep surface cultivation
- Compost (humus) for soil fertility and nutrients.
- Close plant spacing, as in nature.
- Synergistic planting of crop combinations so plants that are grown together enhance each other.
- Carbon-efficient crops
  - planting 60% in dual-purpose seed and grain crops for the production of large amounts of carbonaceous material for compost and significant amounts of dietary calories.
- Calorie-efficient crops
  - planting approximately 30% in special root crops, such as potatoes, burdock, garlic, and parsnips, which produce a large amount of calories for the diet per unit of area.



Bio-intensive raised bed traditional rows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2.
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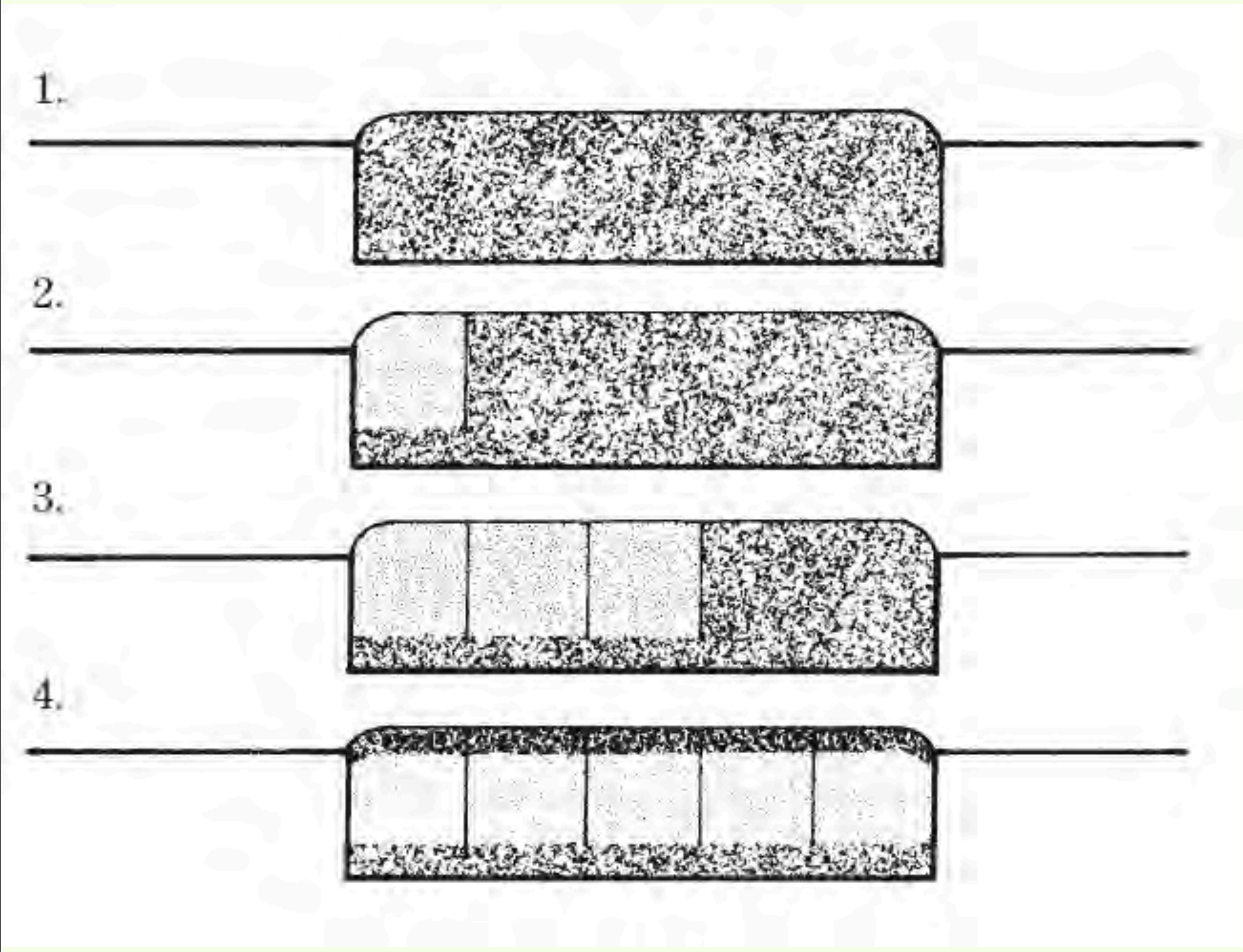
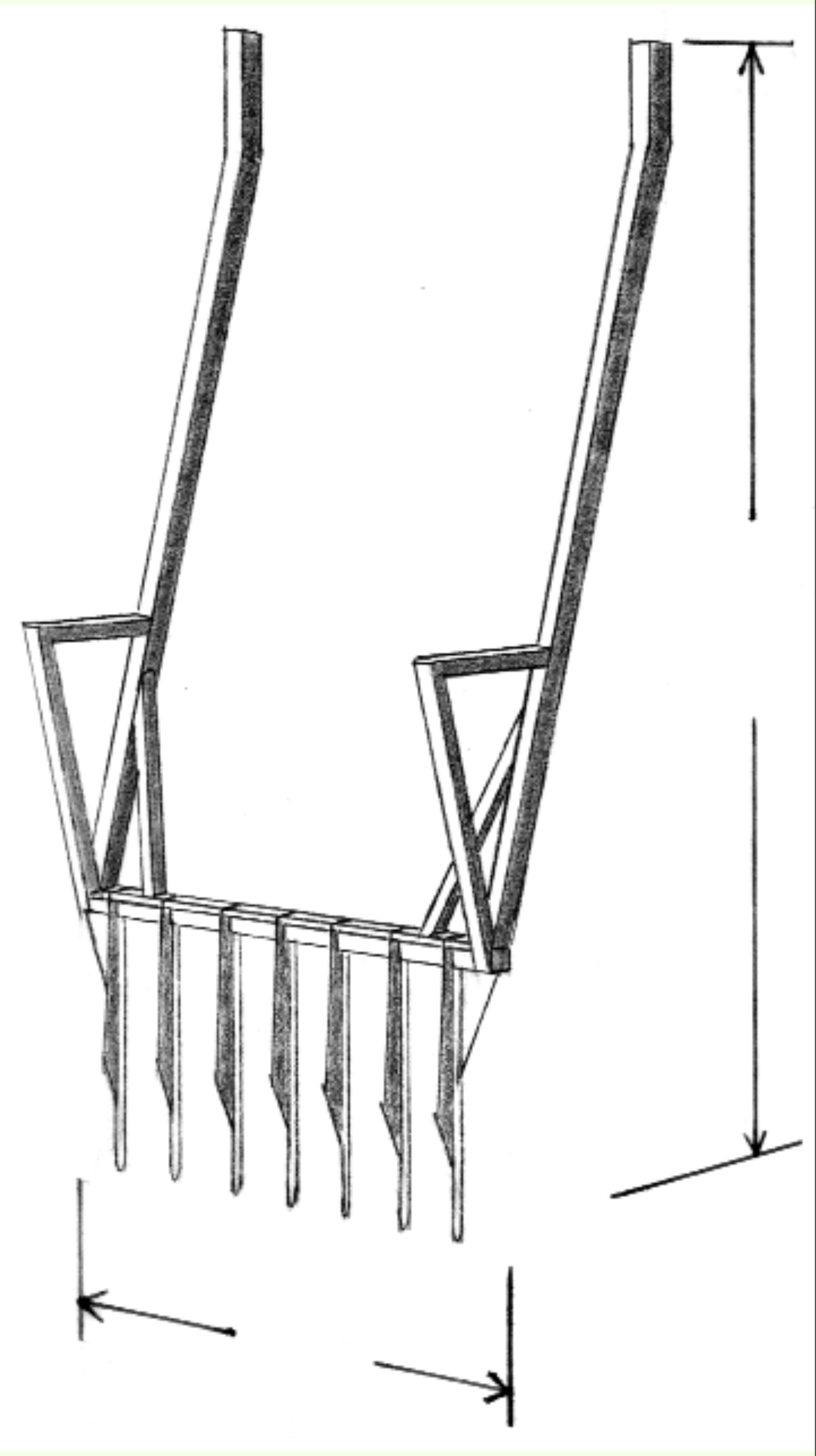
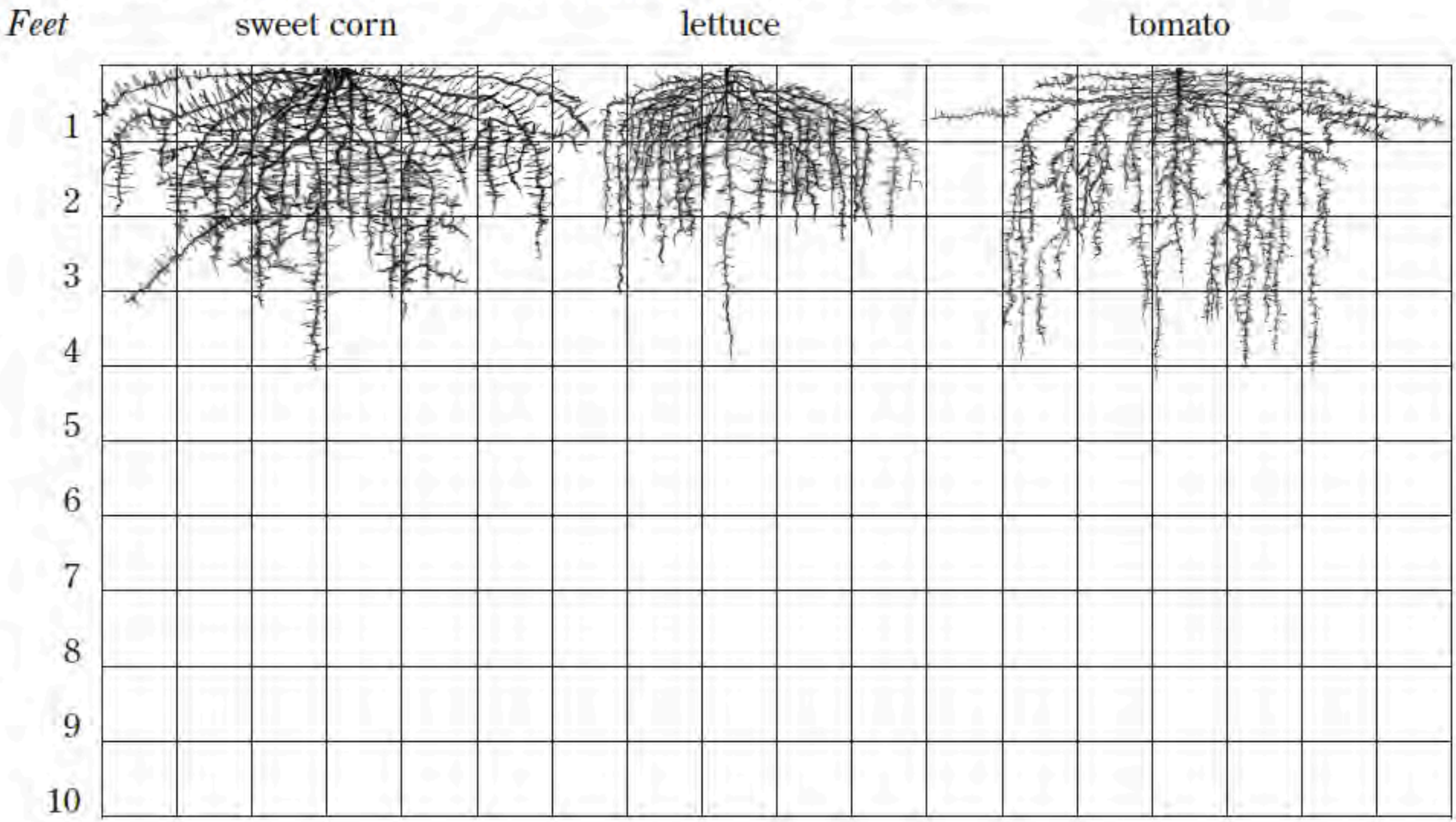
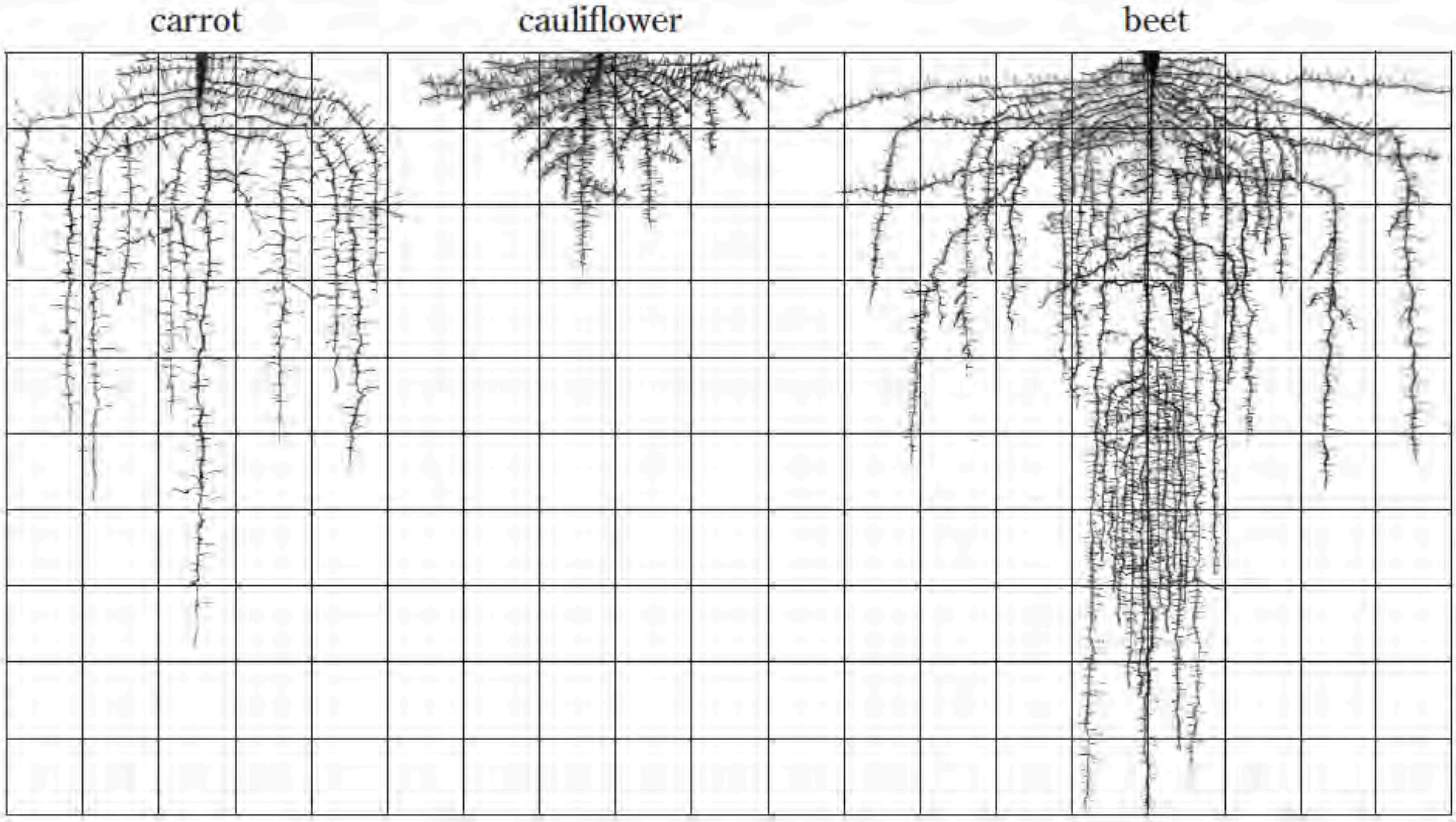
U-Bar Dig





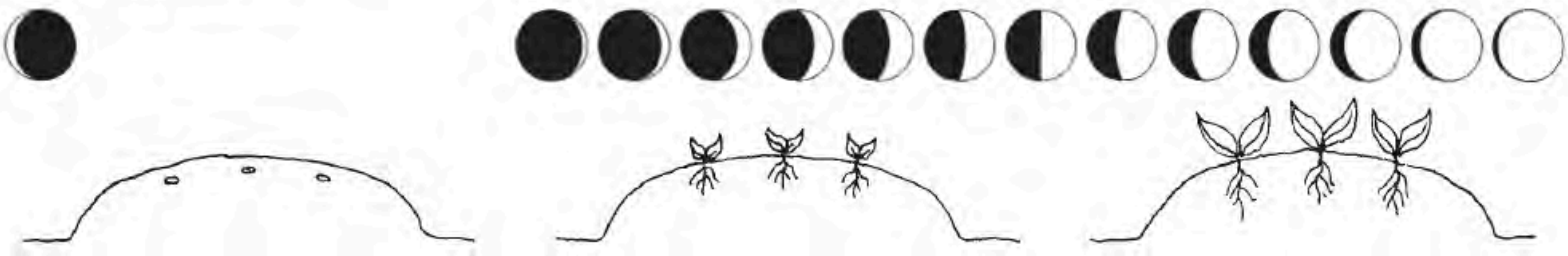
SELECTED VEGETABLE ROOT SYSTEMS SHOWN IN SCALE




carrot
cauliflower
beet

PLANTING BY THE PHASES OF THE MOON

2 days before new moon *First 7 days* *Second 7 days*



Plant short- and extra-long–germinating seeds (most vegetables and herbs) in flats and/or beds

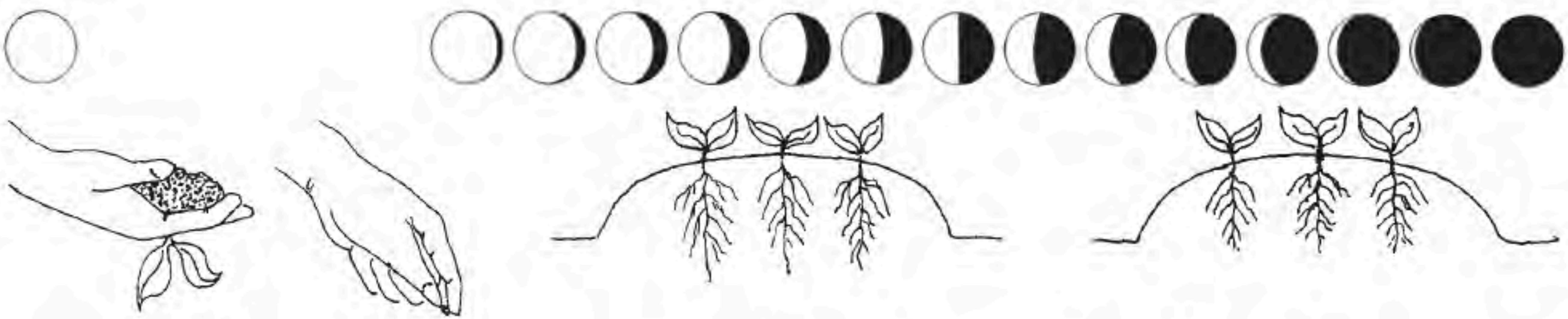
Balanced increase in rate of root and leaf growth

Moonlight +
Lunar Gravity –

Increased leaf growth rate

Moonlight +
Lunar Gravity +

Full Moon *Third 7 days* *Fouth 7 days* *New Moon*

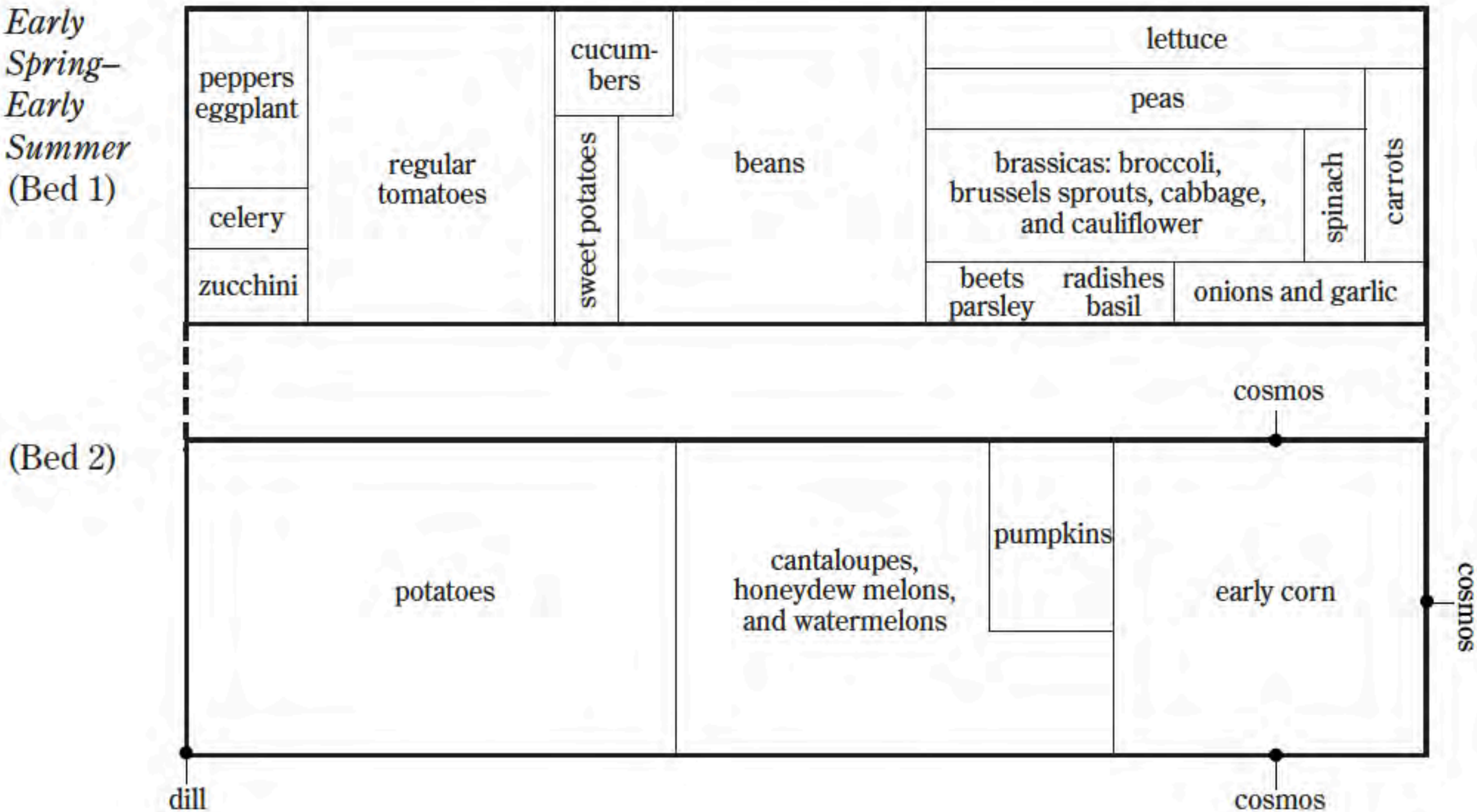


Transplant short- and extra-long–germinating seedlings from flats into beds and plant extra-long–germinating seeds (most flowers) in flats and/or beds

Increased root growth rate
Moonlight –
Lunar Gravity –

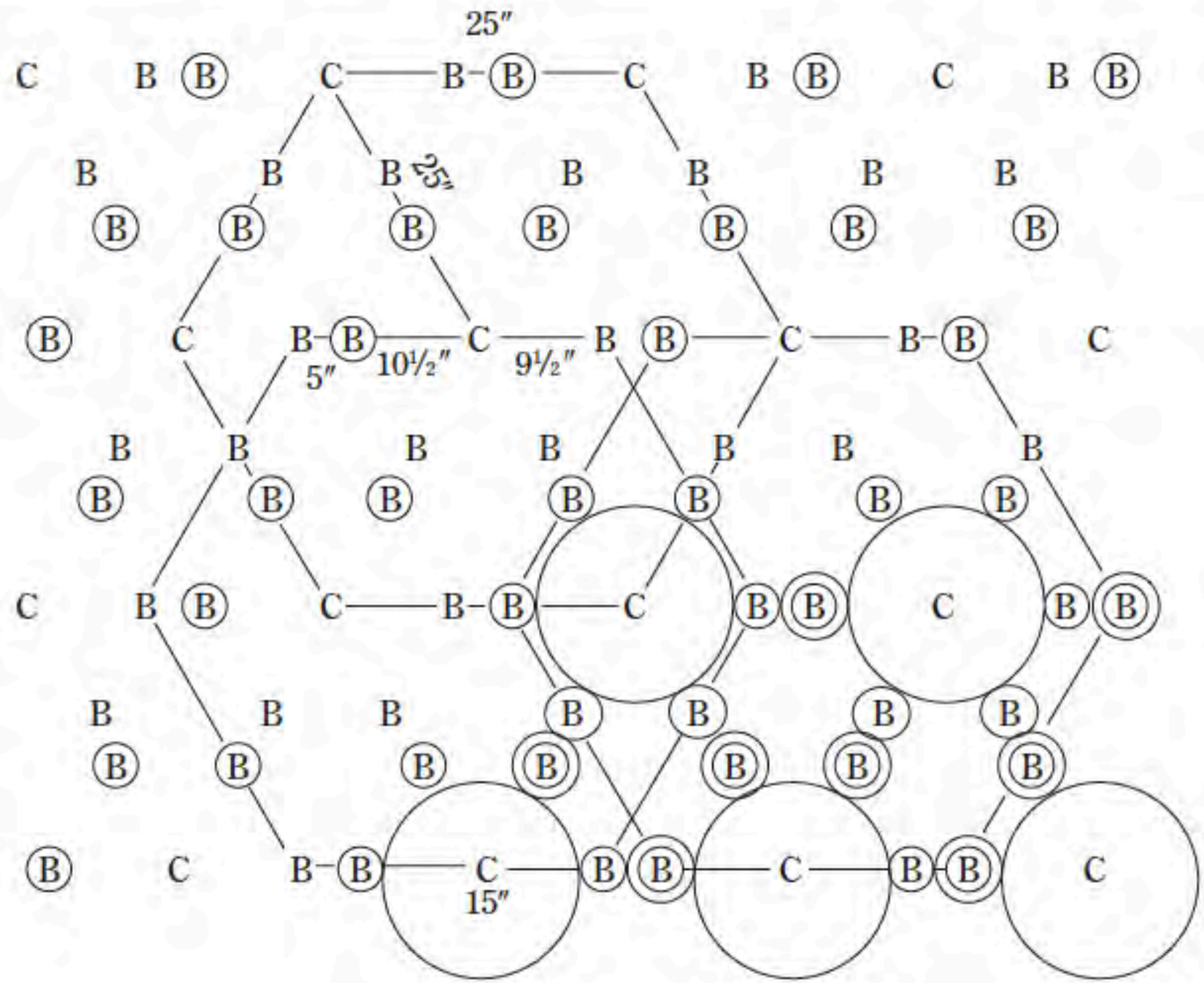
Balanced decrease in rate of root and leaf growth (resting period)
Moonlight –
Lunar Gravity +

ONE-PERSON MINI-GARDEN, *SECOND* YEAR



THREE-CROP COMPANION PLANTING

Circles show average root growth diameters.



C = Corn (15″ C)
B = Beets (4″ C)
(B) = Bush beans (6″ C)

Using the sun/shade technique is one way to make the most of your plants' physically complementary characteristics.

A LIST OF COMMON GARDEN VEGETABLES, THEIR COMPANIONS, AND THEIR ANTAGONISTS[8]

	Companions	Antagonists
Asparagus	Tomatoes, parsley, basil	
Beans	Potatoes, carrots, cucumbers, cauliflower, cabbage, summer savory, most other vegetables and herbs	Onions, garlic, gladiolus, chives
Beans, bush	Potatoes, cucumbers, corn, strawberries, celery, summer savory	Onions
Beans, pole	Corn, summer savory, sunflowers	Onions, beets, kohlrabi, cabbage
Beets	Onions, kohlrabi	Pole beans
Cabbage family (cabbage, cauliflower, kale, kohlrabi, broccoli)	Aromatic plants, potatoes, celery, dill, chamomile, sage, peppermint, rosemary, beets, onions	Strawberries, tomatoes, pole beans
Carrots	Peas, leaf lettuce, chives, onions, leeks, rosemary, sage, tomatoes	Dill